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TRANSMISSION LINE REFURBISHMENT STUDY TOWER FOUNDATION TESTING AND INSPECTION HALTON JCT TO 'OLD' COOKSVILLE TS 'B' 115 kV LINE

Report No 89-139-K

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ABSTRACT

As part of the transmission line refurbishment study, three steel grillage footings at Tower No 15 for the above line were tested under uplift and lateral loads. The measured uplift capacities showed an adequate margin in the factor of safety, in relation to the design maximum loads. The footing uplift capacities were controlled by the local bearing-type of failure in the backfill above the grillage pads as opposed to the lifting of a truncated pyramid of soil mass. A detailed analysis of the native soil/backfill properties is included.

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TABLE OF CONTENTS

	Page
1.0 INTRODUCTION	1
2. SOIL INVESTIGATION	2
2.1 Native Soil and Backfill Materials	2
2.2 Compaction Efficiency of Backfill Material	3
3.0 FIELD LOAD TESTING	3
3.1 Testing Set-up and Procedure	3
3.2 Grillage Test Results	4
3.2.1 Lateral Load Test	4
3.2.2 Uplift Load Tests	5
3.3 Soil Movements	5
4.0 GRILLAGE INSPECTION	6
5.0 CONCLUSIONS	6
REFERENCES	9
TABLES I TO IV	10
FIGURES 1 TO 23	15
APPENDIX A	38
APPENDIX B	45
APPENDIX C	78
DISTRIBUTION	last page

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TRANSMISSION LINE REFURBISHMENT STUDY
TOWER FOUNDATION TESTING AND INSPECTION
HALTON JCT TO 'OLD' COOKSVILLE TS 'B' 115 kV LINE

1.0 INTRODUCTION

A foundation testing program was carried out for 115 kV McGuigan-type towers in the Oakville area as a continuation of the transmission line refurbishment study. A section of line built in 1911 along the old Burlington to Manby right-of-way in the vicinity of Upper Middle Road and Trafalgar Road in the Town of Oakville was selected. The line section designation is NT60 x 13, the "B" line with McGuigan-type towers (ST3-61) along the Halton Jct to the 'Old' Cooksville TS. The details of the above transmission line regarding the test site location, schematic of McGuigan-type towers and grillage foundations are contained in Appendix A/1,2/. Figure 1 shows the location of Tower No's 13, 14 and 15 selected for testing.

This study contains the following:

a) field inspection of selected tower locations
b) in situ testing of the backfill material and native soil
c) laboratory soil testing of native soil and backfill material
d) full-scale load testing of foundations at Tower No 15
e) excavation of grillage footings for visual inspection and calibrating the corrosivity measurements from the Tower Leg Integrity Monitor (TLIM).

The scope of the current refurbishment investigation on the 115 kV TL in the Oakville area was similar to the field and laboratory study performed at Smiths Falls/3/.

Figure 2 shows a schematic of the grillage footings excavated from Tower No 15. Table I summarizes the dimensions of the test footings and the types of field load tests performed.

2.0 SOIL INVESTIGATION

A soil investigation was performed at Tower No's 13, 14 and 15 to determine the nature of the backfill material in relation to the native soil. Soil sampling and in situ testing was performed to quantify the soil strength for analysis of the uplift load tests on the steel grillages at Tower No 15. Continuous standard penetration testing and thick-walled Shelby sampling were completed at each tower leg at Tower No's 13, 14 and 15.

2.1 Native Soil and Backfill Material

The native soils at the selected tower sites varied from a stiff to very stiff reddish-brown clayey silt with some sand to a very dense reddish-brown sandy silt with some clay. Generally, these native soil types can be described as a medium plastic silty soil (ML) according to the Unified Classification System. Free water was absent at the three tower sites within the depths investigated. The average natural moisture content of the native soil was 8 to 10 per cent and an average bulk density of 2300 kg/m^3. The soil data sheets are summarized in Appendix B.

The composition of the backfill material was similar to the native soil as indicated by the grain size analysis data (Appendix B). The average natural moisture content of the backfill varied from 15 to 22 per cent. The average bulk density of the backfill material was 2100 kg/m^3. The bulk density profiles for backfill and native soils obtained by thick-walled Shelby tubes are presented in Figures 3 to 5.

Table II summarizes the dry density data for backfill and native soils from selected tower locations. A range in the coefficient of variances for the dry density was observed for both the backfill and native soil (3 to 17%). The coefficient of variance, COV, for the dry density indicates the degree of uniformity of the native soil deposit and similarly, the uniformity achieved in compaction of the backfill. Larger magnitudes in the COV of the dry density indicate a lesser degree of uniformity or non-homogeneity of the soil deposit with respect to its relative density. At Tower No 15 where three grillage footings were load tested, both the native soil and backfill material indicated similar degrees of variability in the density distributions (4 to 17%). In general, the backfill material had a lower dry density than the native soil.

Profiles of the standard penetration values (N) for the backfill material and native soil are shown in Figures 6 to 8. The average N-value for the backfill material ranged from 10 to 20 blows/0.3 m and the native soil ranged from 30 to 80 blows/0.3 m at the three selected tower locations. Based on the soil classification and the standard penetration test results from three tower sites, the backfill material can be regarded as a stiff cohesive material, and, the native soil can be regarded as a very stiff to hard cohesive soil for the purposes of uplift behaviour of the grillage footings tested. The lower strength properties of the backfill material in comparison to the native soil suggests the uplift capacity of a grillage at these sites is governed predominantly by the backfill strength.

2.2 Compaction Efficiency of Backfill Material

The compaction efficiency of the backfill material was assessed. Table III summarizes the results of standard Proctor tests performed on bagged soil samples. In addition, a one-point Proctor was performed on the backfill material to compare the dry densities obtained by compaction at the natural moisture content (20%) and at optimum moisture content (15%).

Table IV shows the average compaction efficiency achieved for the backfill material at Tower No's 13, 14 and 15. The average maximum dry density obtained by the standard Proctor at Tower No 15, Leg A, was used as the datum. The following observations are noted:

(a) Greater than 97% compaction efficiency was indicated for the backfill material at Tower No's 13, 14 and 15.

(b) Values greater than 100% compaction efficiency in the backfill material was possibly due to variability in the soil gradation and native soil densities.

(c) The dry densities measured (>1850 kg/m^3) at a depth of 2.06 m directly above the grillage members, at Tower No's 13, 14 and 15, indicated 100% compaction efficiency.

3.0 FIELD LOAD TESTING

Full-scale foundation tests were performed at Tower No 15 on three grillage footings (Legs B, C and D as shown in Figure 1). The fourth grillage footing (Leg A) was excavated for visual inspection prior to the field load testing program. The footing at Leg B was tested under a groundline shear load. Uplift load tests were performed on grillages at Legs C and D. These footings (Legs B, C and D) were excavated for corrosion examination after the field load tests.

3.1 Testing Set-up and Procedure

Since the field load testing was performed in the month of January, frost-protection measures were implemented to eliminate frost effects (Figure 9). Two types of foundation tests were performed at Tower No 15, lateral groundline shear and vertical uplift, and outlined as follows:

The lateral groundline shear test was performed on Leg B at Tower No 15. The stub angle of the test footing was pulled horizontally near groundline by means of a hydraulic ram reacting against a bulldozer (Figure 10). A dynamometer was used to measure the applied load. The horizontal load was applied in increments of approximately 5 kN until the horizontal displacement at the groundline reached 312 mm. Figure 11 shows the lateral displacement of the stub angle at the groundline due to the horizontal applied load.

The test set-up for the vertical uplift tests consisted of a pair of 10 m long steel I-beams resting on timber bearing pads (1.5 x 1.5 m) and a stacked pair of 534 kN (60 ton) hydraulic rams reacting against a steel seat to apply the uplift loads (Figure 12). The uplift load was applied in-line with the

tower leg stub to avoid bending of the stub during testing. The loads were applied in increments of 10 to 20 kN. Each load increment was maintained for about 5 minutes or until significant movement of the footing had occurred before proceeding to the next load step. Near the final stages of loading, each increment of load was maintained for 10 minutes or longer depending on the footing response. The loading was applied until the footing was uplifted in excess of 100 mm. The first test footing (Leg C) was loaded continuously to establish the ultimate capacity. The other grillage footing (Leg D) was tested with one loading and unloading cycle at about 40% of the anticipated capacity.

The movements of soil mass around the uplift test footings was monitored by means of telltale rods at different locations and depths (Figure 13). The telltales consisted of 6 mm steel rods in a PVC cased hole (25 mm diameter). The movements of each telltale rod were measured by electronic displacement potentiometers mounted on a remotely supported batter board. Figure 14 shows the field instrumentation set up for the pullout tests performed on Legs C and D at Tower No 15. The ground movements were recorded at each loading step.

3.2 Grillage Test Results

Table V summarizes the results of the field load tests performed at Tower No 15. Figure 15 shows the load-displacement curve for the groundline shear load test performed at Leg B. Figures 16 and 17 show the load-displacement curves for the uplift load tests performed at Legs C and D respectively. The load-displacement data is tabulated in Appendix C.

3.2.1 Lateral Load Test

The following observations of the lateral load test on Leg B can be made:

a) Control of the desired load increment was slightly erratic; the applied load tended to slowly increase in magnitude during the hold intervals.

b) Under the maximum applied lateral load of 39 kN, the lateral deflection of the stub angle was 313 mm. This large deflection was due to bending of the unsupported stub angle.

c) The lateral footing resistance at 25 mm displacement was 14 kN.

d) The load-displacement curve was non-linear and exhibited some creep behaviour, particularly at the higher load levels (Figure 15).

e) A cavity formed behind the stub angle due to the applied lateral load as a result of bending of the stub angle at a depth of 1.1 m below the groundline; just below the overlap of the angle members (Figure 23).

3.2.2 Uplift Load Tests

The predicted reaction loads for these grillage foundations with McGuigan-type towers ranged from 54 kN (12 kips) to 71 kN (16 kips)/4/. The following observations can be made regarding the uplift tests on Legs C and D at Tower No 15:

(a) The maximum loads applied were as follows: (i) Leg C resisted 156 kN with a corresponding uplift displacement of 116 mm and (ii) Leg D resisted 111 kN with a corresponding displacement of 136 mm. Both grillages had the same geometry, dimensions and similar backfill properties.

(b) The measured footing resistance at 25 mm displacement were as follows; (i) Leg C resistance was 90 kN and (ii) Leg D was 67 kN.

(c) At Tower No 15, the uplift resistance measured at 25 mm displacement was equal to or higher than the predicted reaction loads.

(d) The ultimate uplift capacity at Leg D was lower than Leg C due to larger creep movements observed at Leg D under hold loads (Figures 16 and 17).

(e) The load-displacement response of these test footings was non-linear and exhibited significant creep behaviour particularly at higher load levels.

(f) During the uplift test on Leg D, unloading from 70 kN to 20 kN followed by reloading to 70 kN was performed. Under this cyclic applied load, the grillage response was fairly linear in behaviour, similar to the initial uplift loading response (Figure 17). This footing behaviour indicates an elastic response to loading and unloading at approximately 40% of the ultimate capacity.

3.3 Soil Movements

Instrumentation of the two uplift test footings aided to identify the nature of failure and zone of soil movement. Figures 18 and 19 show the measured soil uplift movements at various depths under maximum applied loads for Legs C and D respectively. Both grillages (Legs C and D) failed due to a local soil bearing-type mode of failure as indicated by the localized soil movements around the grillage members.

Considering the localized mode of failure, the mobilized soil bearing pressure under maximum applied load was estimated to range from 340 to 480 kPa (6100 to 9500 psf). The soil bearing pressure corresponding to 25 mm deflection was estimated to range from 200 to 275 kPa (4000 to 5500 psf).

The moisture content at a depth of 2.1 m, just above the grillage members for Legs C and D, was higher (22%) than at Legs A and B (14%) (Figure 22 and Table B1 in Appendix B). The higher natural moisture content (22%) at Legs C and D possibly affected the grillage performance since the plastic limit for this fine-grained ML soil-type was 20 to 25%.

4.0 GRILLAGE INSPECTION

A preliminary field inspection of excavated grillages from Tower No 15 was made after the load testing. Figures 20 to 23 depict some of the field activities during the excavation process at Tower No 15.

Measurements of the corrosion current and potentials by the Tower Leg Integrity Monitor (TLIM) were made on these grillage footings (Legs A, B, C and D from Tower No 15) and other tower locations. Also, a detailed laboratory corrosion inspection was performed on excavated grillage footings retrieved from this section of 115 kV TL. The details of the grillage corrosion study are reported elsewhere/5,6/.

5.0 CONCLUSIONS

A field foundation investigation was performed along a section of the 115 kV TL with McGuigan-type towers between the Halton Jct to 'Old' Cooksville TS 'B' line. The foundation study consisted of a detailed soil investigation of the backfill material and native soil, full-scale foundation testing and corrosion inspections. The following summarizes the major findings:

a) Better than 95% compaction efficiency was achieved for the backfill material at Tower No's 13, 14 and 15.

b) Displacements in excess of 100 mm were measured under the maximum applied uplift load on grillage Legs C and D. At 25 mm uplift displacement, the measured grillage resistance corresponded to the predicted reaction loads.

c) The measured ultimate capacity showed a variability of 30% for the grillages tested (Legs C and D) at the same tower location (Tower No 15) of the same geometry and size.

d) Both grillages (Legs C and D) tested in uplift, failed in local bearing through the backfill material despite the high compaction efficiency obtained during installation. In contrast, the design foundation capacity was originally calculated assuming a generalized mode of failure as an inverted truncated cone of backfill material being uplifted which was not observed in these and other field load tests/3/.

e) Both uplift and lateral groundline shear load-displacement curves exhibited non-linear responses and significant amounts of creep movement.

f) Visual inspection of excavated grillages was performed to assess the degree of corrosion and to estimate the remaining integrity of the foundation.

Based on the recent study of grillage foundations, the following warrants further considerations in the refurbishment and upgrading of old transmission lines:

(a) The foundation uplift capacities can vary as much as 30%, even at the same tower location, despite good compaction of the backfill material. The variability in the foundation capacity from tower to tower locations may likely be larger still.

(b) The ultimate uplift capacity of a grillage may often be controlled by a local bearing-type of failure in the backfill above the grillage members, especially if the backfill material is cohesive in nature and the spacing between the grillage members largely compares to the width of the individual member. Therefore, soil failure in local shear should be checked.

(c) The performance and integrity assessment of grillage foundations along old tower lines requires a thorough soil investigation as an integral part of a tower line refurbishment and/or an upgrading proposal.

(d) Further studies are required to relate the Tower Leg Integrity Monitor (TLIM) data to visual corrosion inspections of excavated foundations.

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The successful completion of this foundation study is a result of a team effort and assistance provided by many departments of Ontario Hydro. The following are acknowledged for their valuable contributions:

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REFERENCES

1. Memorandum to Mr. J.S. McConnach, Transmission System Planning from Mr. F. Rimmer, Central Region regarding Transmission Line Refurbishment. February 26, 1987.

2. Memorandum to Mr. P.W. Barnett, Lines, Stations and Miscellaneous Projects, Pickering NGS 'B' from Mr. J.L. Phillips, Transmission Lines Programs Department re Transmission Line Refurbishment Studies - Oakville Area. File No 841-4419 T5, SP8766.01. November 24, 1988.

3. Tsang, R.H.K. and Radhakrishna H.S. "Transmission Line Refurbishment Study Tower Foundation Inspection and Testing - Smiths Falls to Kingston - 115 kV TL cct 51K". Research Division Report No 88-183-K, 1988.

4. Private communication with Messrs H. Dey and I. Hathout, Design and Development Transmission, Transmission Lines, April 6, 1989.

5. Memorandum to Mr. A.G. Vorauer, Civil Research from Mr. A.C. Headon, Metallurgical Research regarding TL Refurbishment Study - Oakville Tower Foundation Corrosion Survey, March 13, 1989, File No 827.47(T).

6. Memorandum to Mr. M.P. Enders, Pickering NGS 'B' Construction site from Mr. J.L. Phillips, Design and Development, Transmission Lines regarding Foundation Corrosion Survey on McGuigan Towers, March 16, 1989, File No 35454P, 841-4830, Construction/Spec.

TABLE 1

GRILLAGE FOUNDATIONS TESTED AT TOWER NO 15

Footing Number	Embedment Depth, D (m)	Length & Width of Grillage, B (m)	Embedment Ratio, D/B	Test Performed (*)
Leg "A" (SW)	2.083	0.686	3.00	1
"B" (SW)	2.286	0.686	3.33	1, 2
"C" (NW)	2.159	0.686	3.14	1, 3
"D" (NE)	2.153	0.686	3.13	1, 3

Note (*)

1 - Grillage excavated for corrosion examination
2 - Tested under groundline shear
3 - Tested in uplift load

Grillage details see Figure 2.
Soil bearing area of steel grillage base = 0.3045 m^2 or 3.28 $ft.^2$

TABLE 2

DRY DENSITY MEASUREMENTS

	BACKFILL MATERIAL*		NATIVE SOIL**	
Tower Number	Range in Avg Dry Density (kg/m^3)	COV of Dry Density (%)	Range in Avg Dry Density (kg/m^3)	COV of Dry Density (%)
13	1783 - 1910	4 - 12	2008	9
14	1841 - 2076	3 - 14	21005	6
15	1793 - 2049	5 - 17	2114 - 2179	4 - 16

Note

* Calculations based on sampling at 3 to 4 tower legs tested at each tower location in backfill material

** Calculations based on sampling 1 to 2 locations tested in native soil

Avg. = Average of values in vertical soil profile

COV = Coefficient of variance of values in vertical soil profile

TABLE 3

RESULTS OF STANDARD PROCTOR TESTING OF BACKFILL MATERIALS

Tower* Number	Maximum Dry Density (kg/m^3)	Optimum Moisture Content (%)
15 Leg "A" (SE)	1846	14.2
15 Leg "A" (SE)	1841	15.6
Average Proctor Density	1844	15

One point proctor dry density = 1722 kg/m^3 at natural moisture content 20%

Note (*)

Two bag samples were obtained from Tower No. 15 Leg "A" from a depth of 2.13 m (directly above grillage members)

TABLE 4

AVERAGE COMPACTION EFFICIENCY OF THE BACKFILL MATERIAL

Tower Number	Compaction * Efficiency (%)
13	97 - 104
14	99 - 113
15	97 - 111

Note (*)

Compaction efficiency (%) is defined as the ratio of the "in-place" dry density to the maximum dry density obtained from the Standard Proctor test (measured values obtained from Tables 2 and 3)

TABLE 5

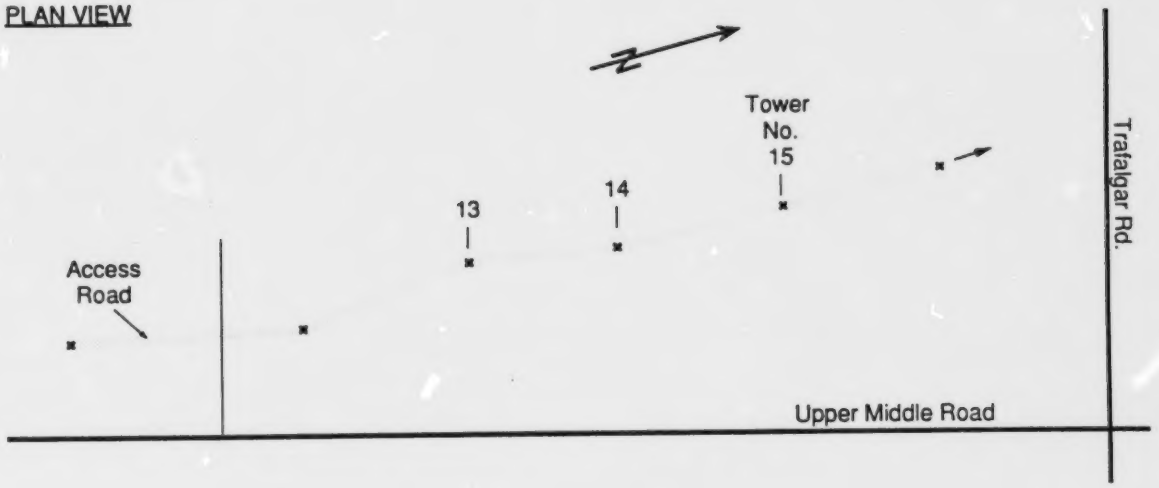
GRILLAGE CAPACITIES AT TOWER NO 15

Footing * Number	Embedment Ratio, D/B	Test Performed	Footing Capacity (kN) at 2.5 mm Deflection	Maximum Applied Load (kN)	Footing Deflection at Maximum Load (mm)
Leg "A" (SW)	3.00	-	-	-	-
"B" (SW)	3.33	Lateral Shear	14	39	313
"C" (NW)	3.14	Uplift	90	156	116
"D" (NE)	3.13	Uplift	67	111	136

Note (*)

Grillage dimensions are given in Table 1 and Figure 2

PLAN VIEW



PLAN VIEW

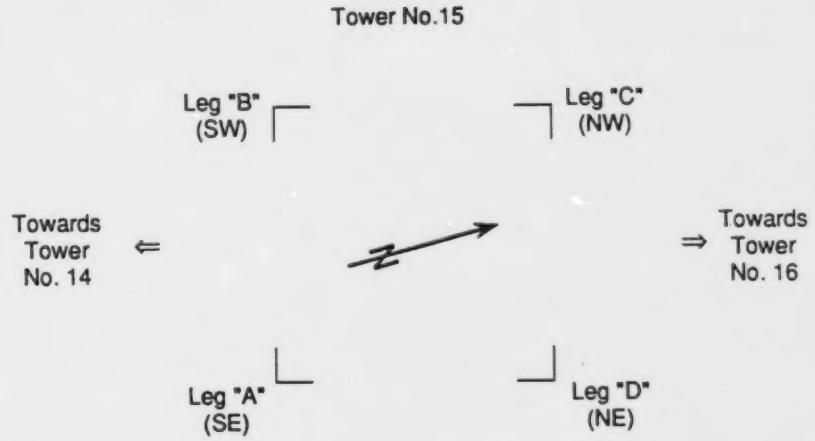


FIGURE 1

LOCATION OF TEST SITE

FIGURE 1-G16-RD

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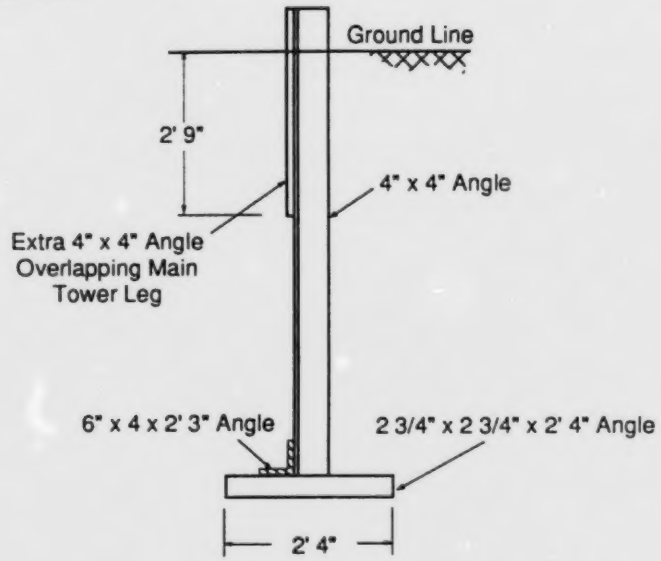
CROSS - SECTION



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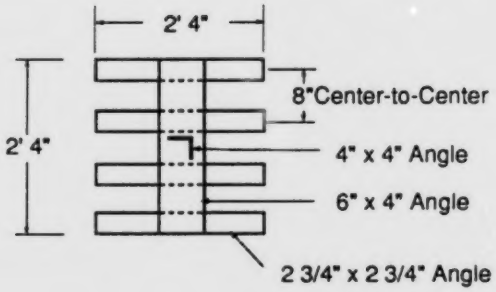

Net Soil Bearing Area of Grillage Pad = 3.28 ft.^{2}

END VIEW

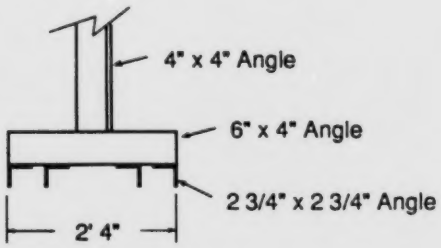

FIGURE 2

SCHEMATIC OF GRILLAGES EXCAVATED AT TOWER NO 15

FIGURE 2-G16-RD

FIGURE 3 BULK DENSITY FROM THICK-WALL SHELBYS

TOWER 13 BACKFILL MATERIAL VS NATIVE

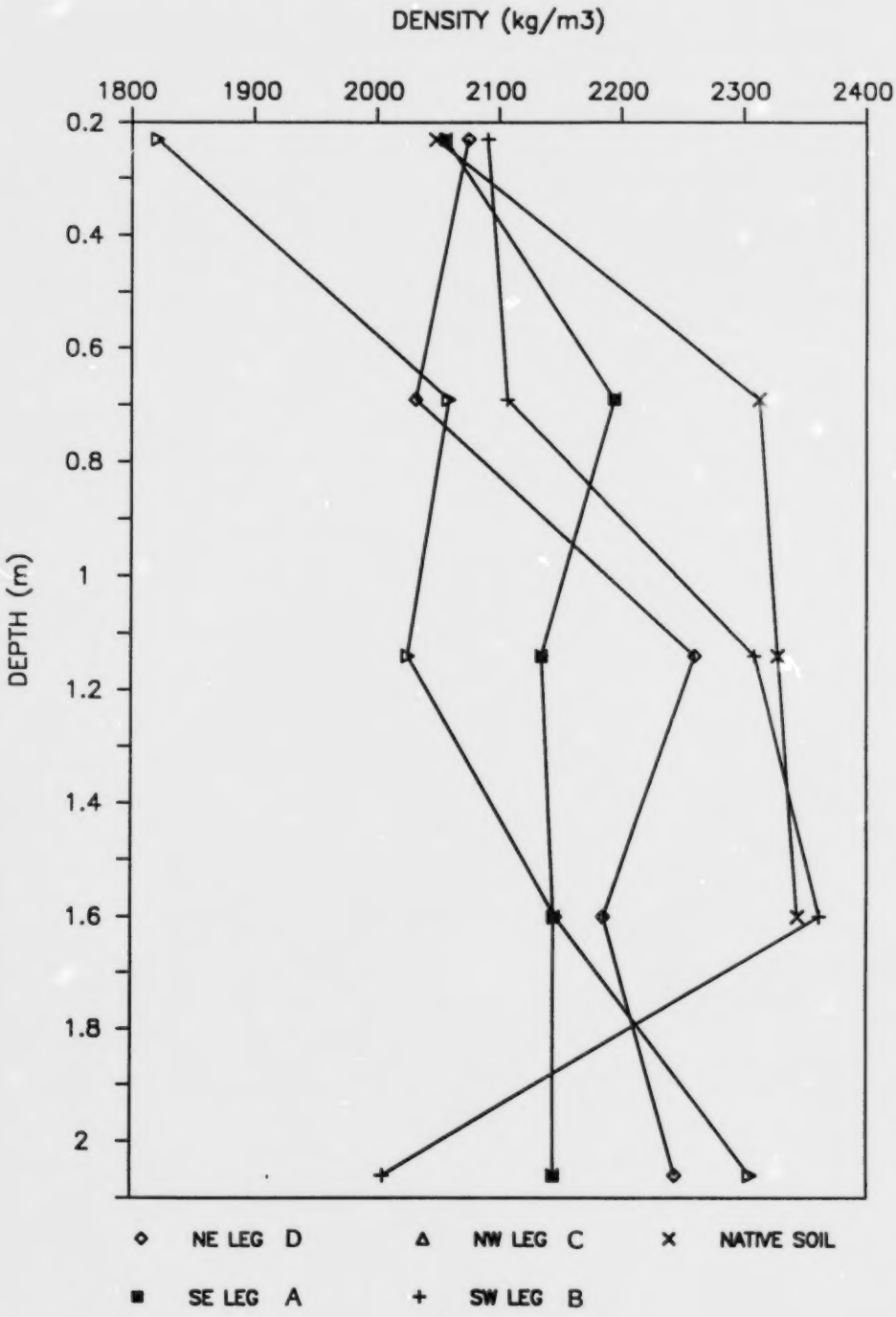

FIGURE 4 BULK DENSITY FROM THICK-WALL SHELBYS

TOWER 14 BACKFILL MATERIAL VS. NATIVE

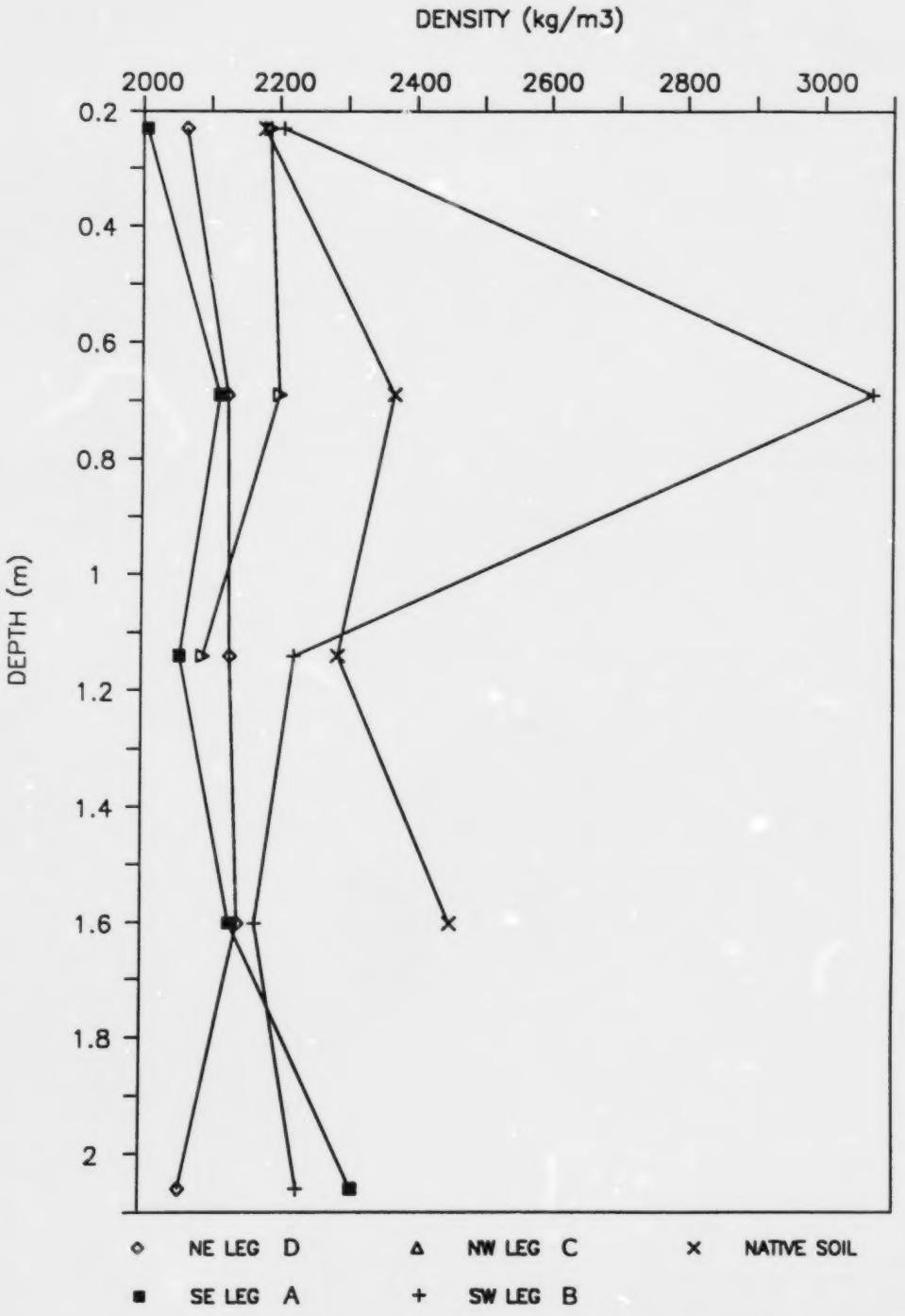

FIGURE 5 BULK DENSITY FROM THICK-WALL SHELBYS

TOWER 15 BACKFILL MATERIAL VS. NATIVE

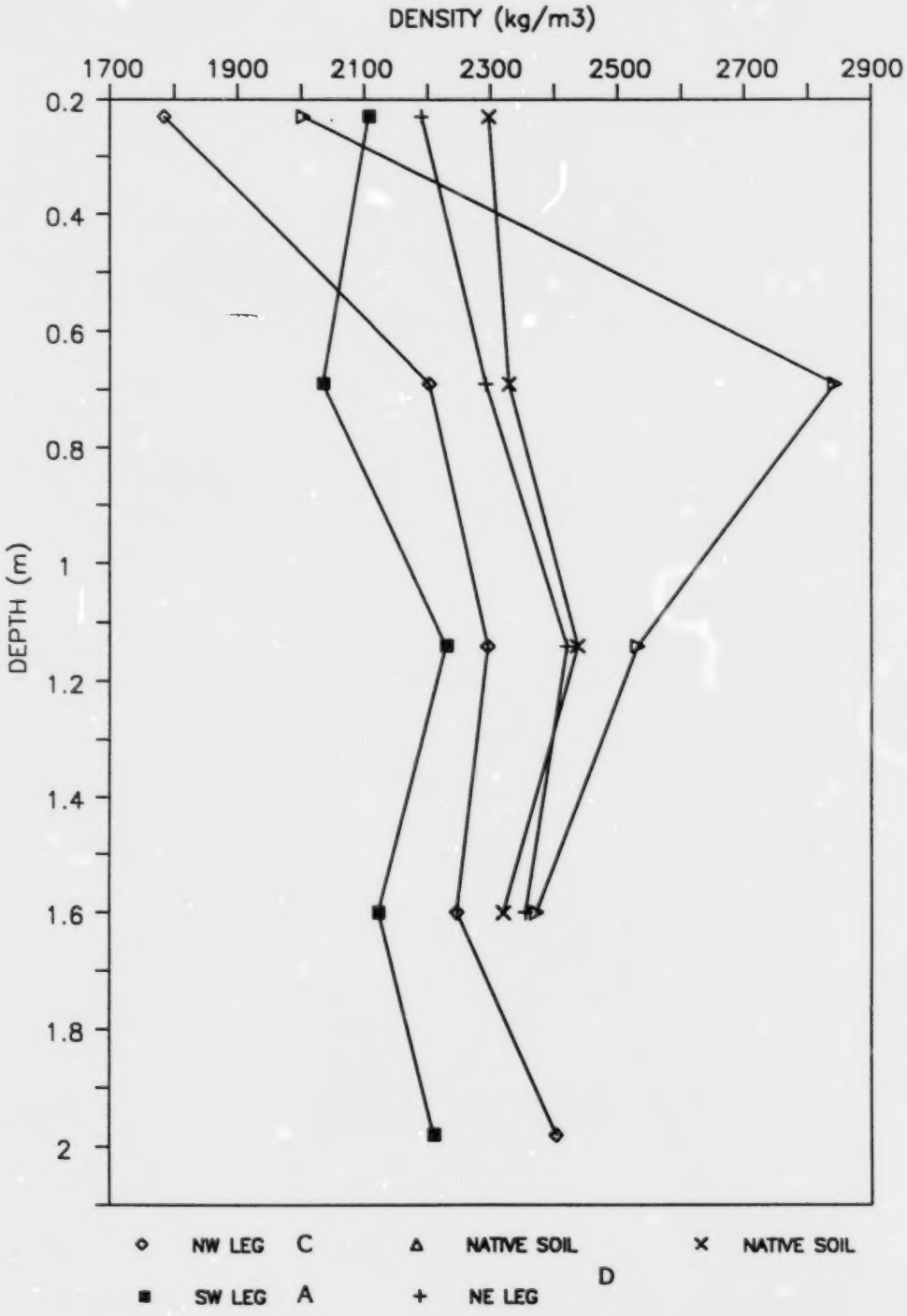

FIGURE 6 STANDARD PENETRATION TESTING

TOWER 13 BACKFILL MATERIAL VS NATIVE

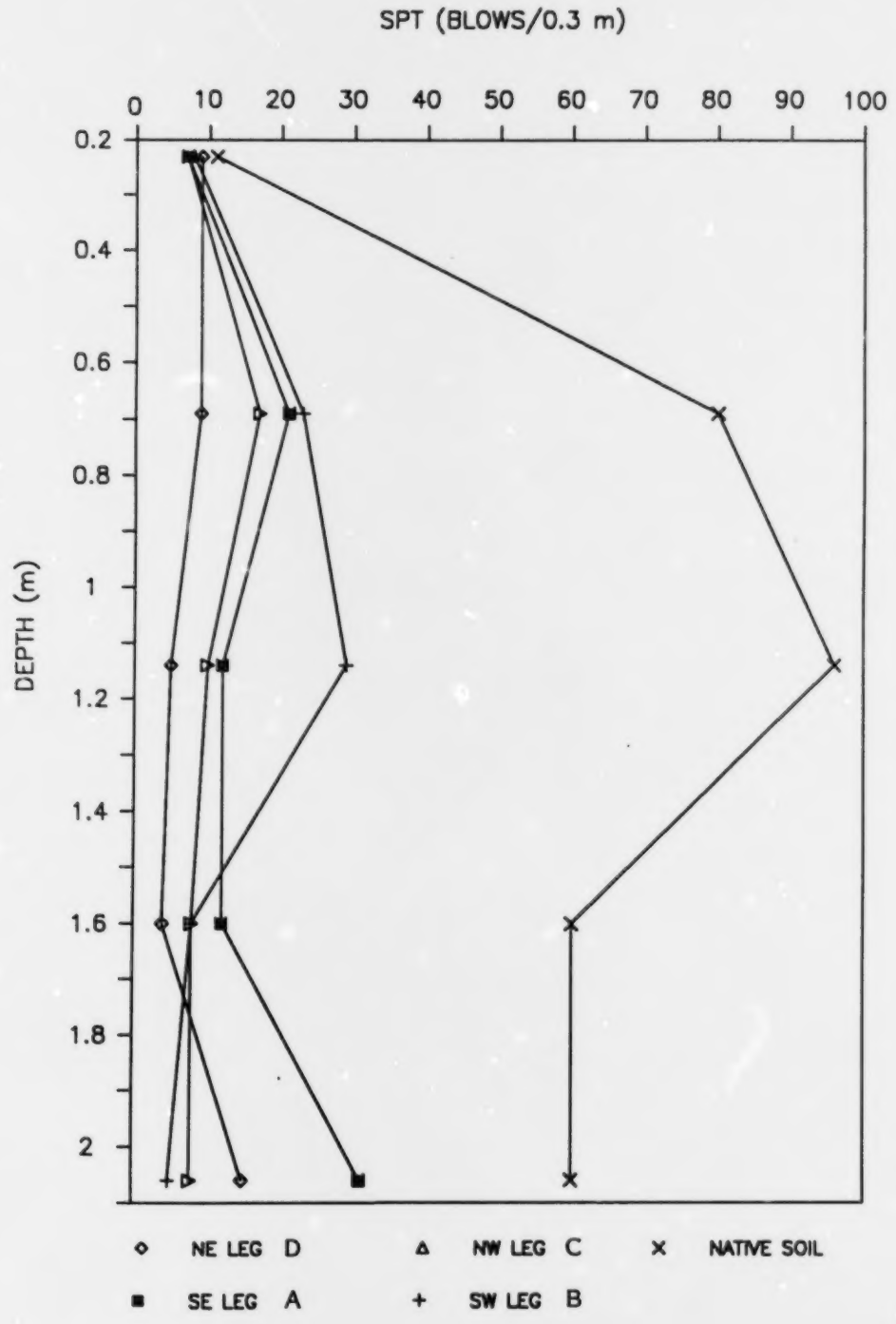

FIGURE 7 STANDARD PENETRATION TESTING

TOWER 14 BACKFILL MATERIAL VS. NATIVE

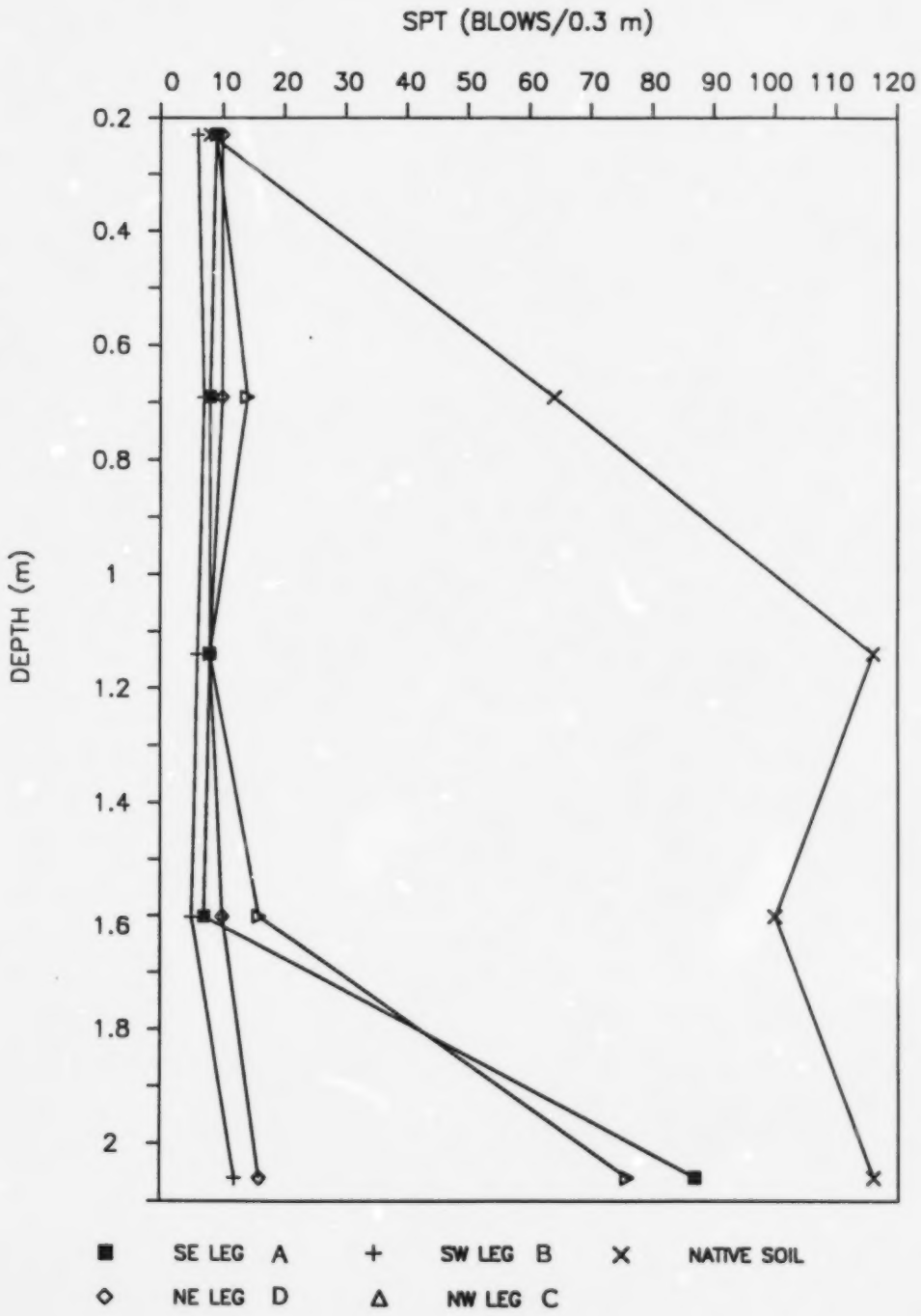

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FIGURE 8 STANDARD PENETRATION TESTING

TOWER 15 BACKFILL MATERIAL VS. NATIVE

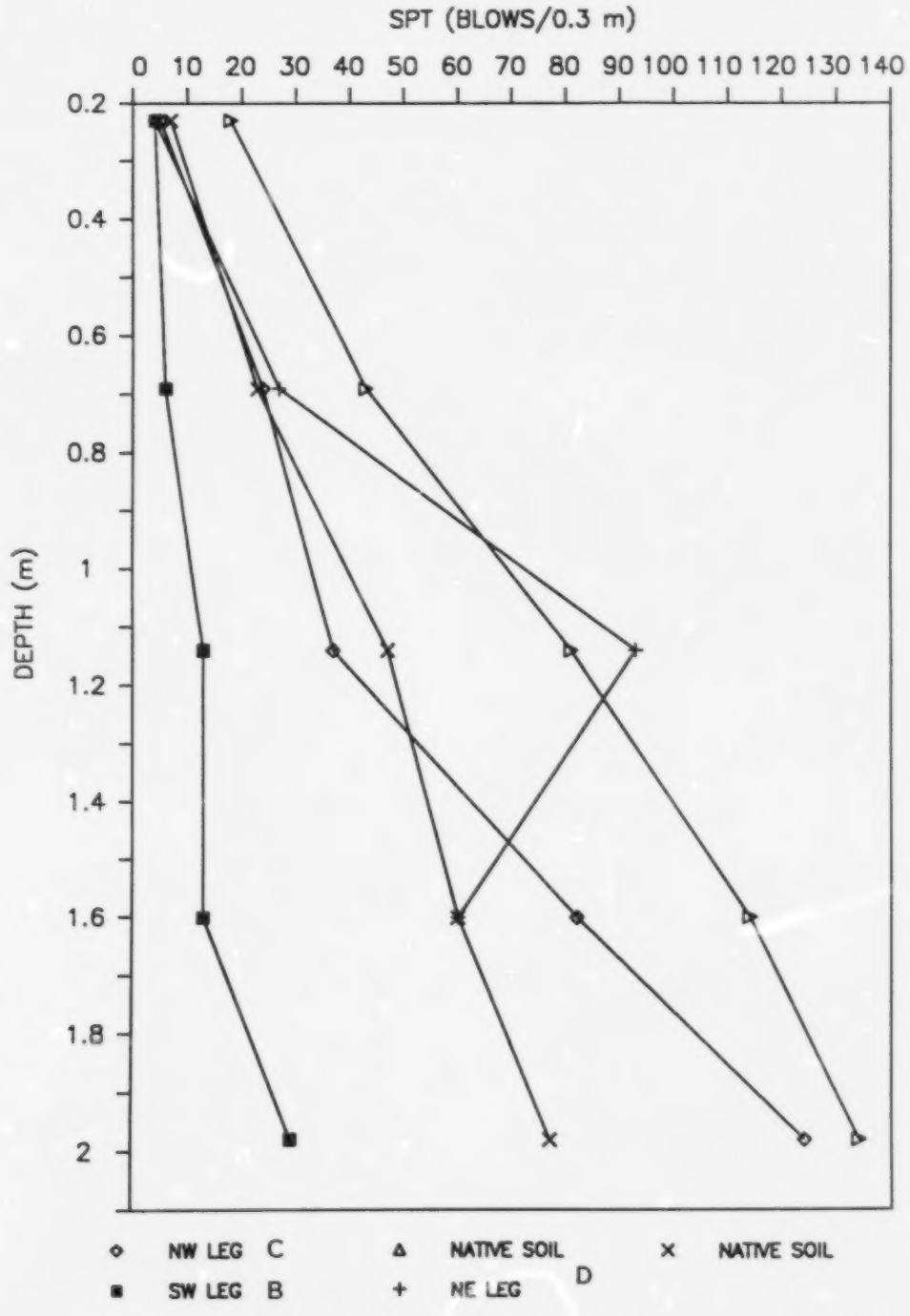


FIGURE 9

BALES OF HAY WERE USED TO INSULATE THE FOOTINGS FROM FROST. DURING THE TESTING PHASE, WOODEN SHELTERS WITH PROPANE HEATERS PROVIDED WARMTH TO THE FOOTINGS TO PREVENT FROST PROBLEMS

FIGURE 10

TYPICAL SET-UP FOR LATERAL SHEAR LOAD TEST ON GRILLAGE FOOTING.
BULLDOZER WAS USED FOR A REACTION

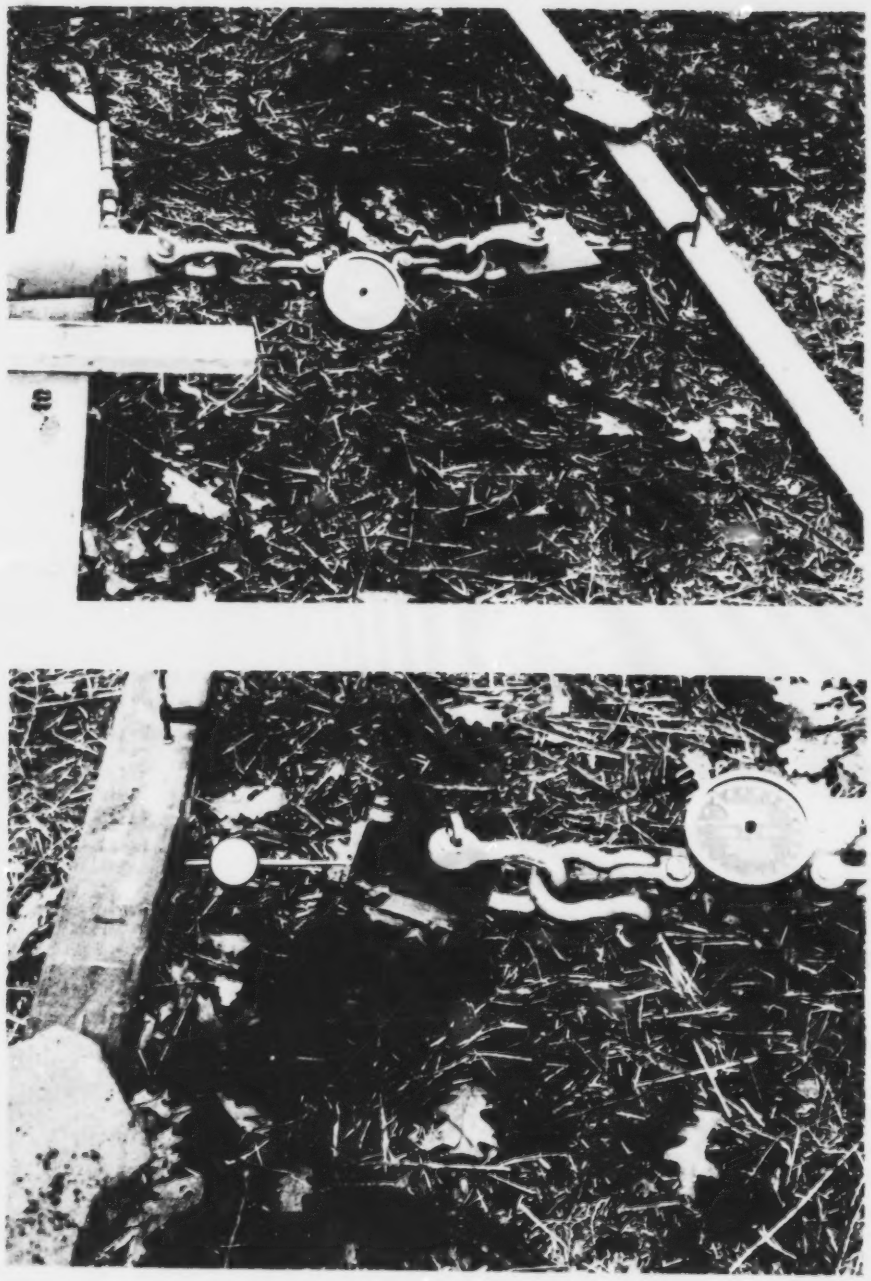
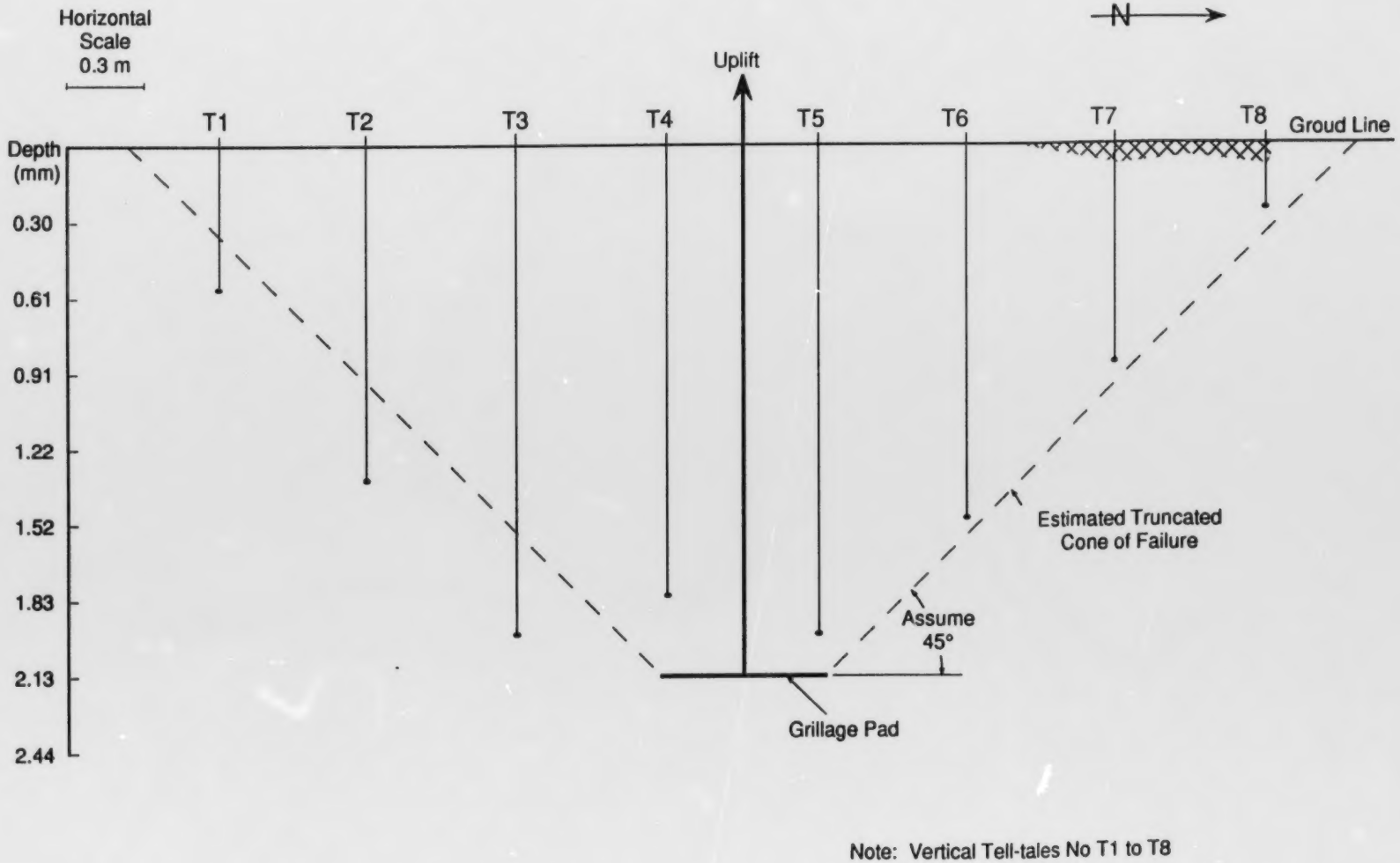


FIGURE 11

A DYNAMOMETER WAS USED TO RECORD THE APPLIED LATERAL LOAD AND A DIAL GAUGE TO MEASURE DISPLACEMENTS IN THE FOOTINGS DURING THE GROUNDLINE SHEAR LOAD TEST

FIGURE 12

TYPICAL SET-UP FOR UPLIFT TESTING OF GRILLAGE FOOTINGS
AT TOWER NO. 15



Note: Vertical Tell-tales No T1 to T8

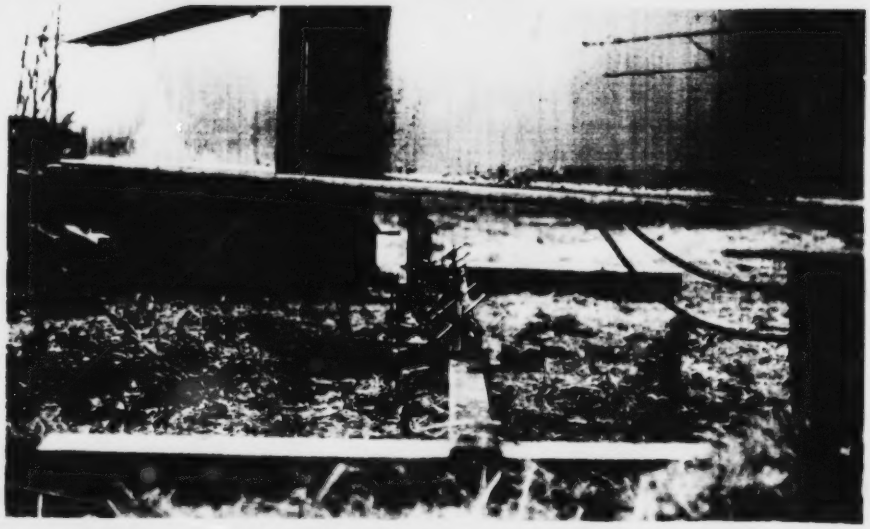
FIGURE 13

TYPICAL INSTRUMENTATION LAYOUT TO MONITOR SOIL MANOMETER AT TOWER NO 15, LEGS "C" AND "D"

89-139
FIGURE 13-G16-RD

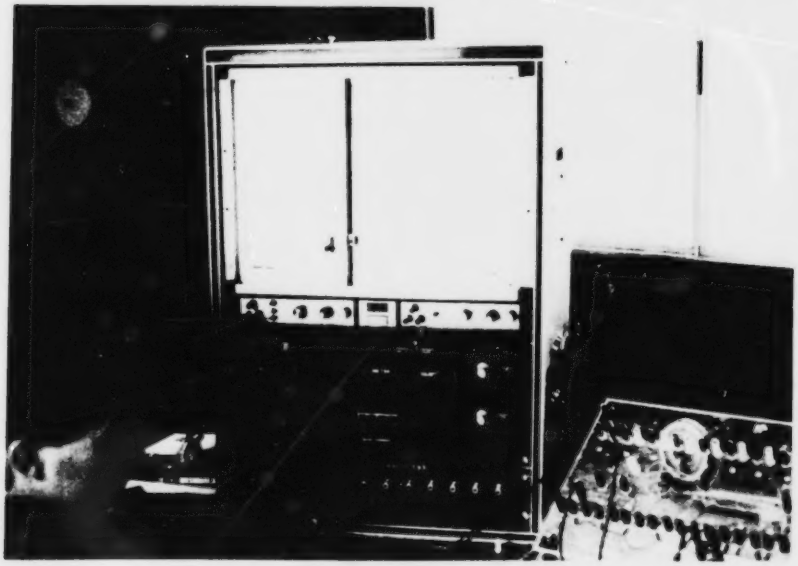
FIGURE 14 (a)

TELL-TALES INSTALLED FOR MONITORING SOIL MEASUREMENTS DURING UPLIFT TESTING



(b)

DISPLACEMENT GAUGES ON A BATTER BOARD



(C)

X-Y PLOTTER FOR LOAD DEFORMATION CURVE DURING TESTING

179884-RD

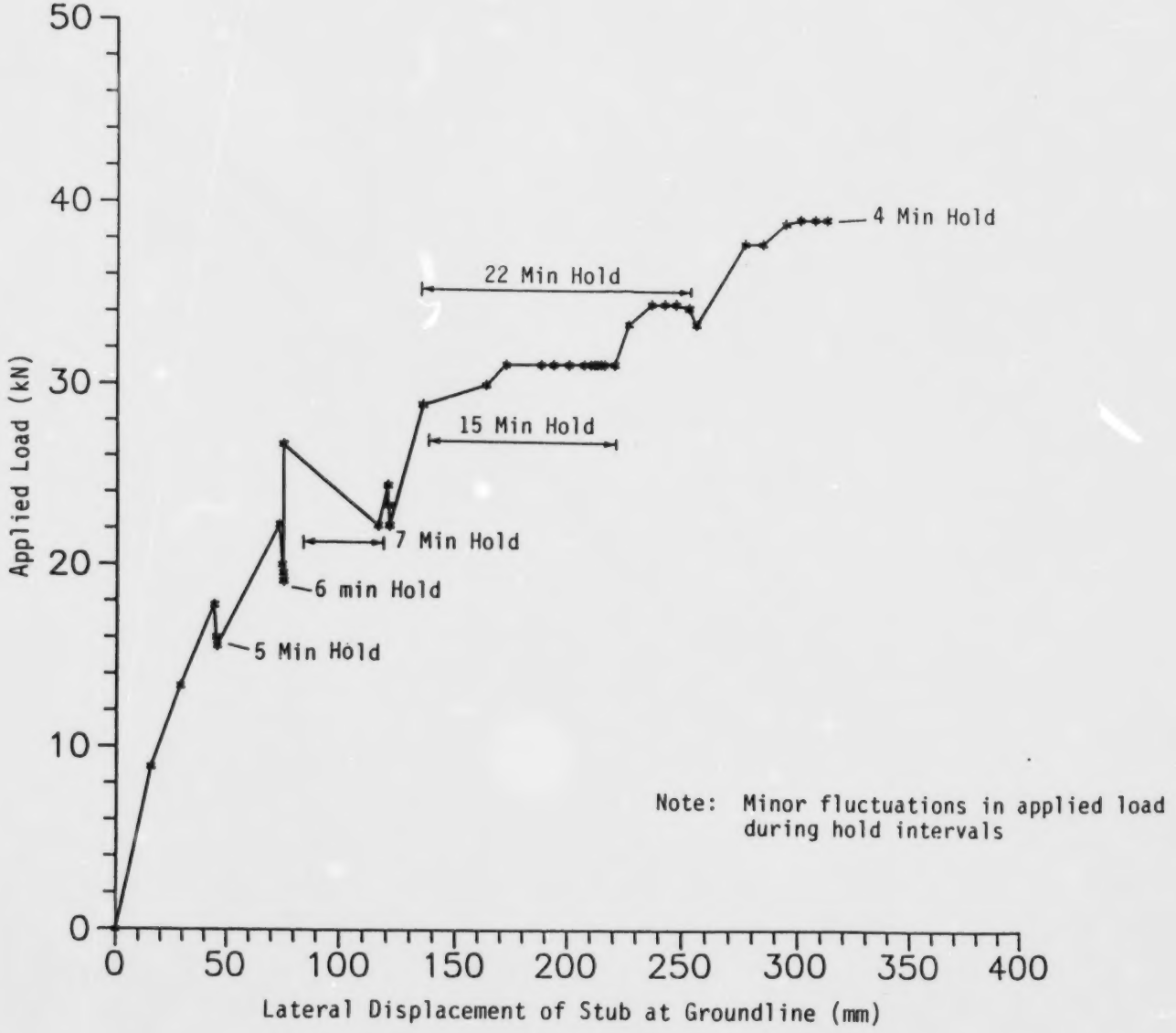


FIGURE 15

LOAD-DISPLACEMENT CURVE FROM GROUNDLINE SHEAR LOAD TEST ON LEG B FOOTING NO. 15

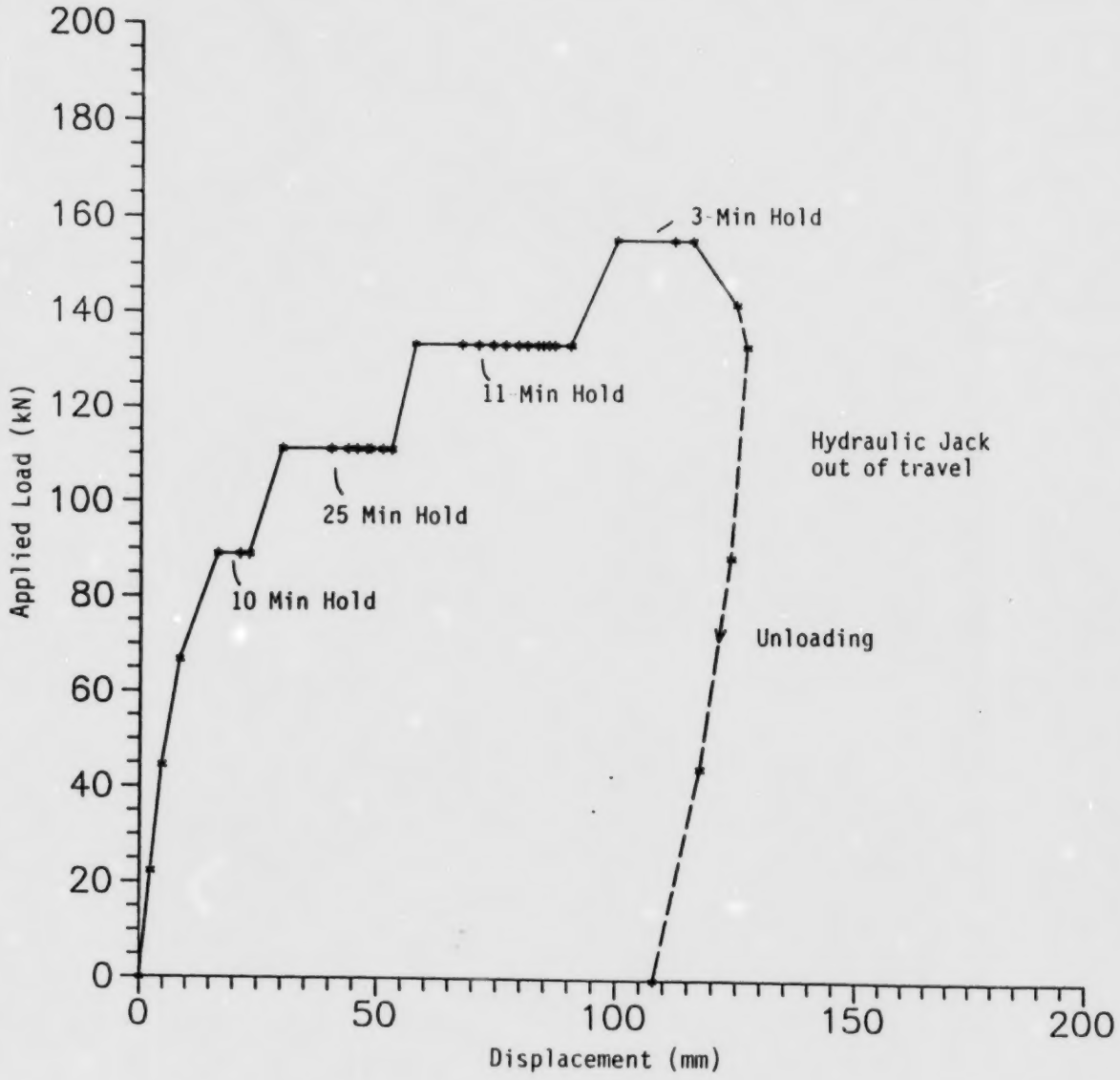


FIGURE 16
LOAD-DISPLACEMENT CURVE FROM UPLIFT LOAD
TEST ON LEG C, FOOTING NO. 15

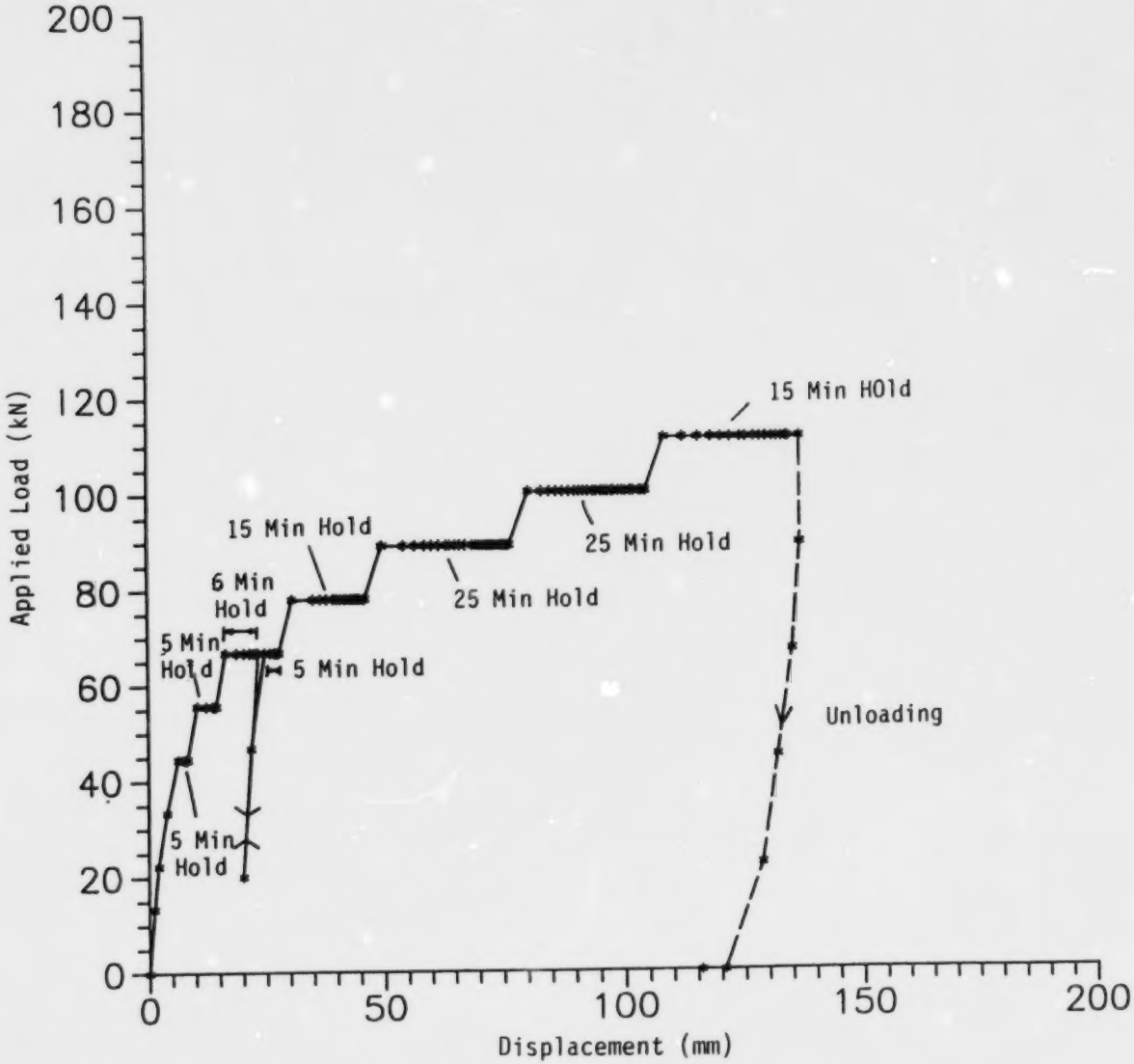
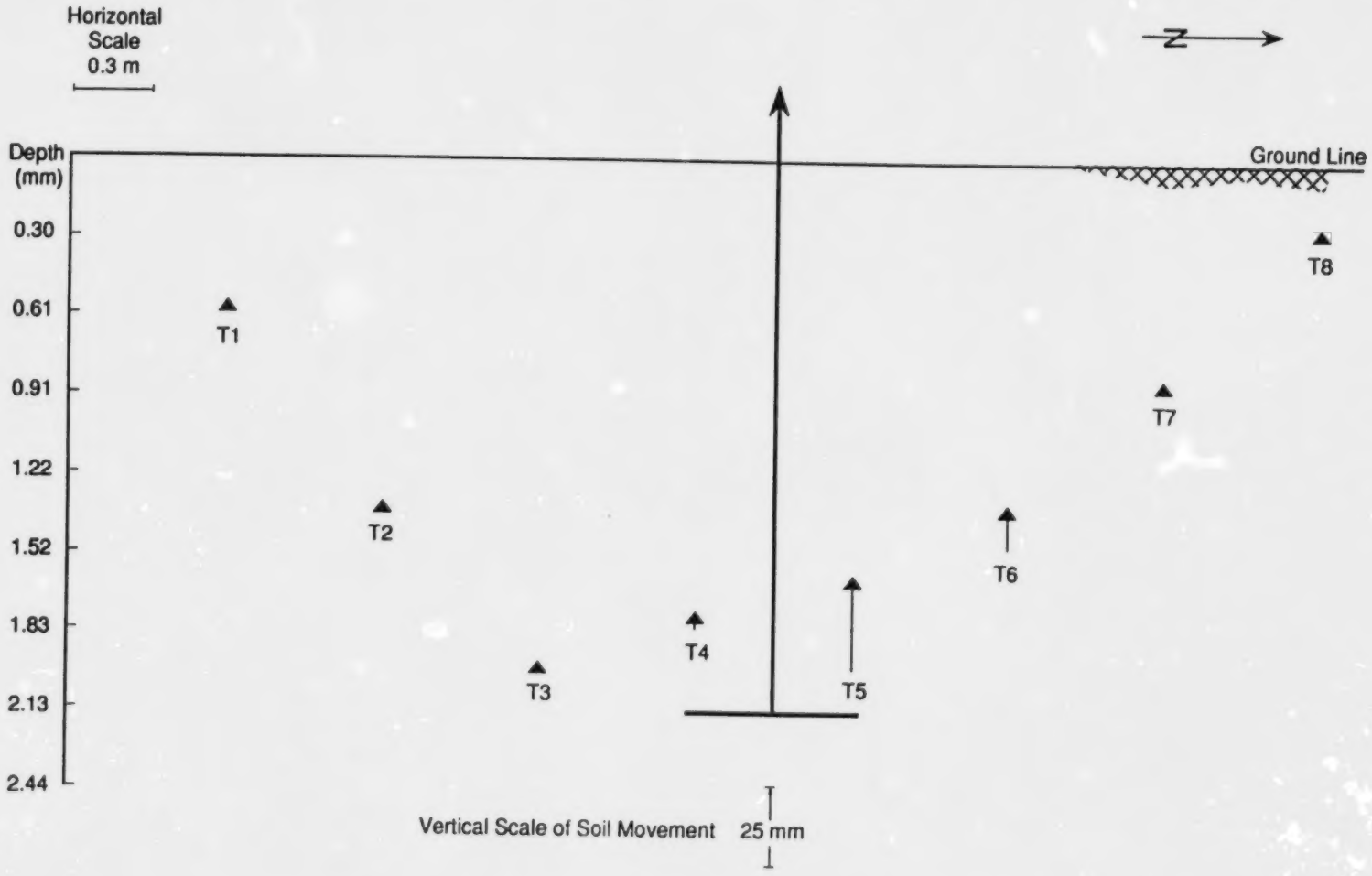


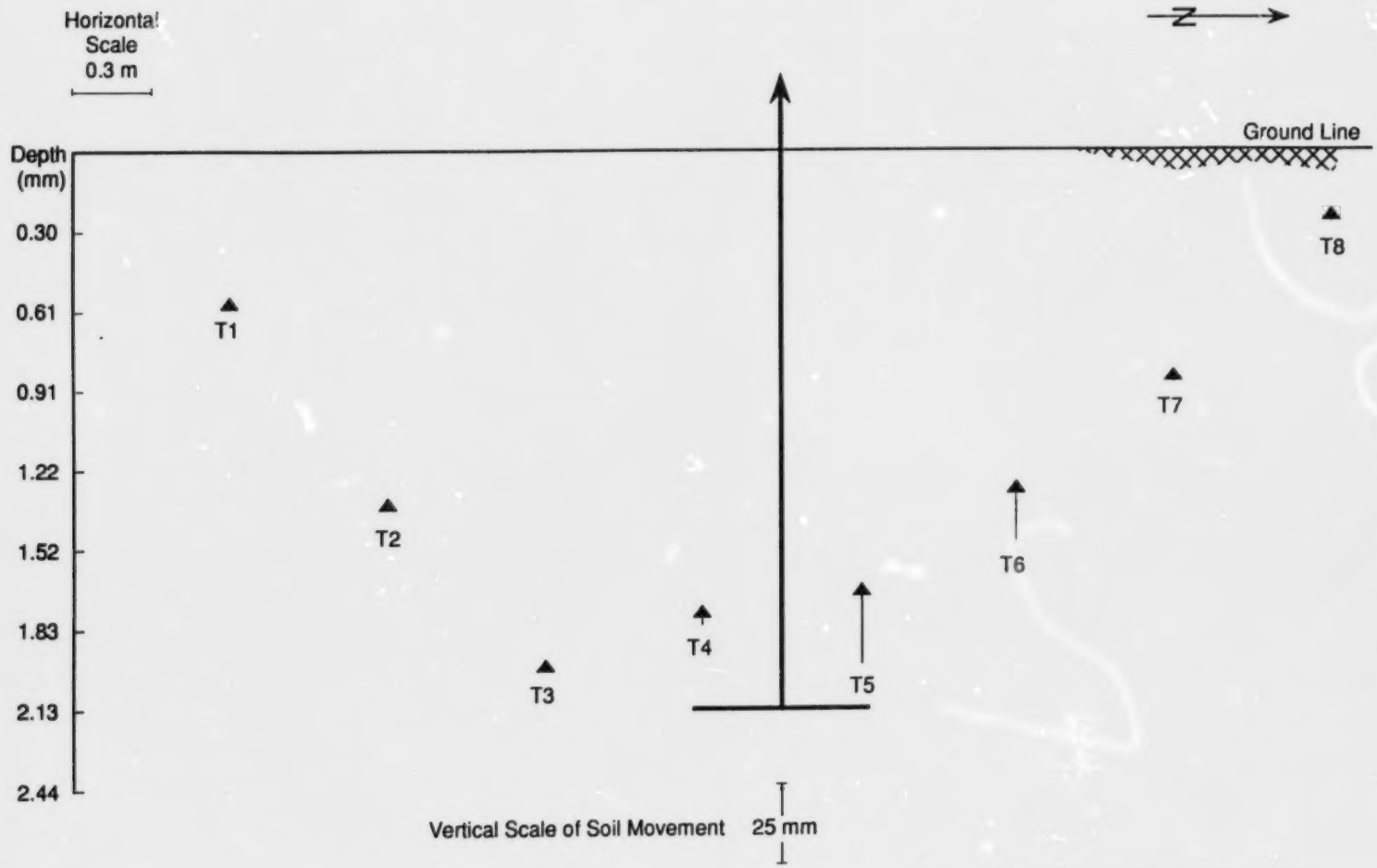
FIGURE 17
LOAD-DISPLACEMENT CURVE OF UPLIFT LOAD TEST FOR FOOTING NO. 15D



Note: Tell-tale No T1 - T4 and T7 and T8 measured movements less than 1 mm

FIGURE 18

**SOIL MOVEMENTS UNDER MAXIMUM APPLIED LOAD (155 kN)
AT TOWER NO 15 LEG "C"**



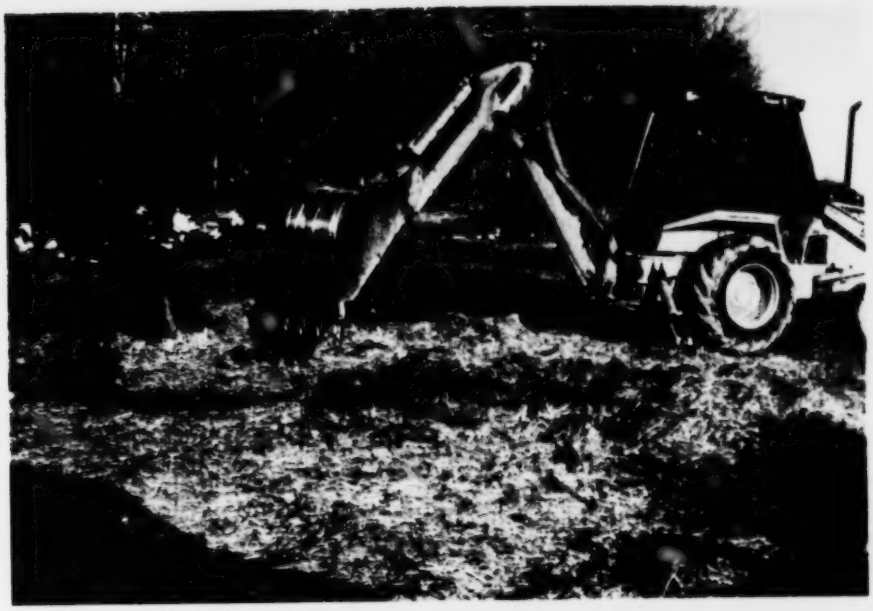
Note: Tell-tale No T1, T2, T3, T7 and T8 measured movements less than or equal to 1 mm

(*) Tell-tale No T5 dropped into void after load step of 89 kN

FIGURE 19

SOIL MOVEMENTS UNDER MAXIMUM APPLIED LOAD (111 kN)
AT TOWER NO 15 LEG "D"

FIGURE 19-G16-RD



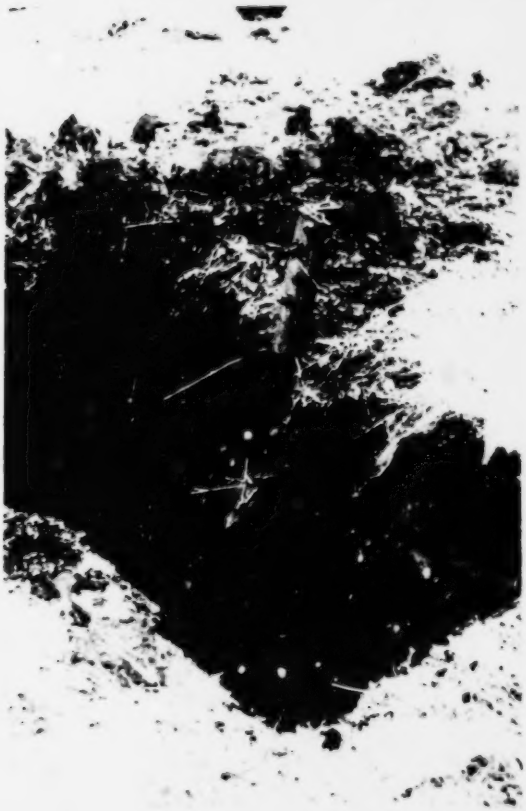


FIGURE 20

EXCAVATION OF GRILLAGE FOOTINGS AT TOWER NO 15
NOTE DISCOLOURATION ON THE MAIN LEG BELOW
THE GROUND LEVEL

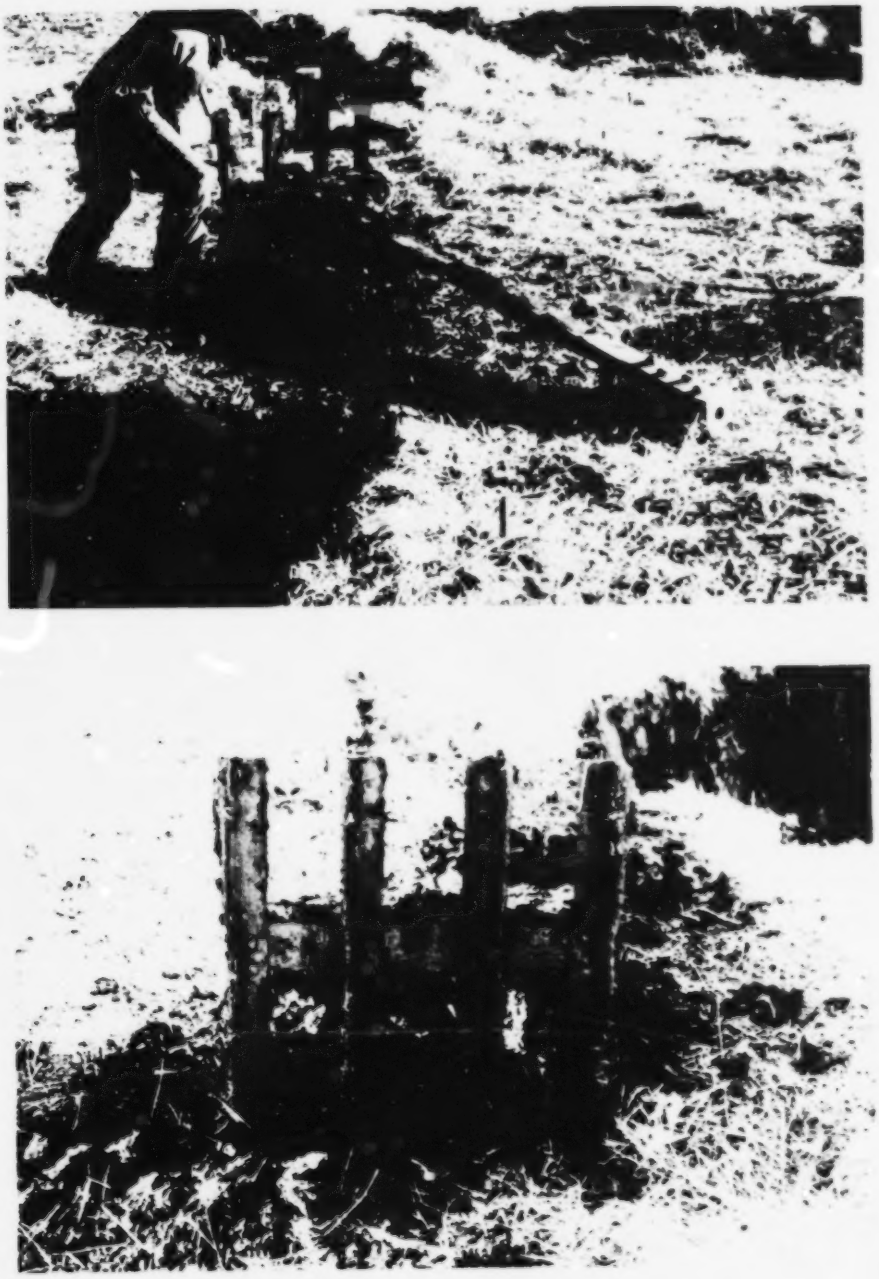


FIGURE 21

TYPICAL GRILLAGE EXCAVATION FROM TOWER NO 15

FIGURE 22

EXCAVATION OF GRILLAGE FOOTINGS AT TOWER NO 15.
THE MOISTURE CONTENT AT A DEPTH OF 2.1 m WAS
HIGHER (22%) AT LEGS C AND D THAN AT
LEGS A AND B (14%)

FIGURE 23

EXCAVATED GRILLAGES WERE EXAMINED FOR CORROSION IN THE LABORATORY. LATERAL LOAD TESTING RESULTED IN BENDING OF THE MAIN LEG JUST BELOW THE OVERLAP OF ADDITIONAL ANGLE AT TOWER NO 15

APPENDIX A

General Inforamtion

Figure A1 TL Layout

Figure A2 Site Location (Sketch JP-1)

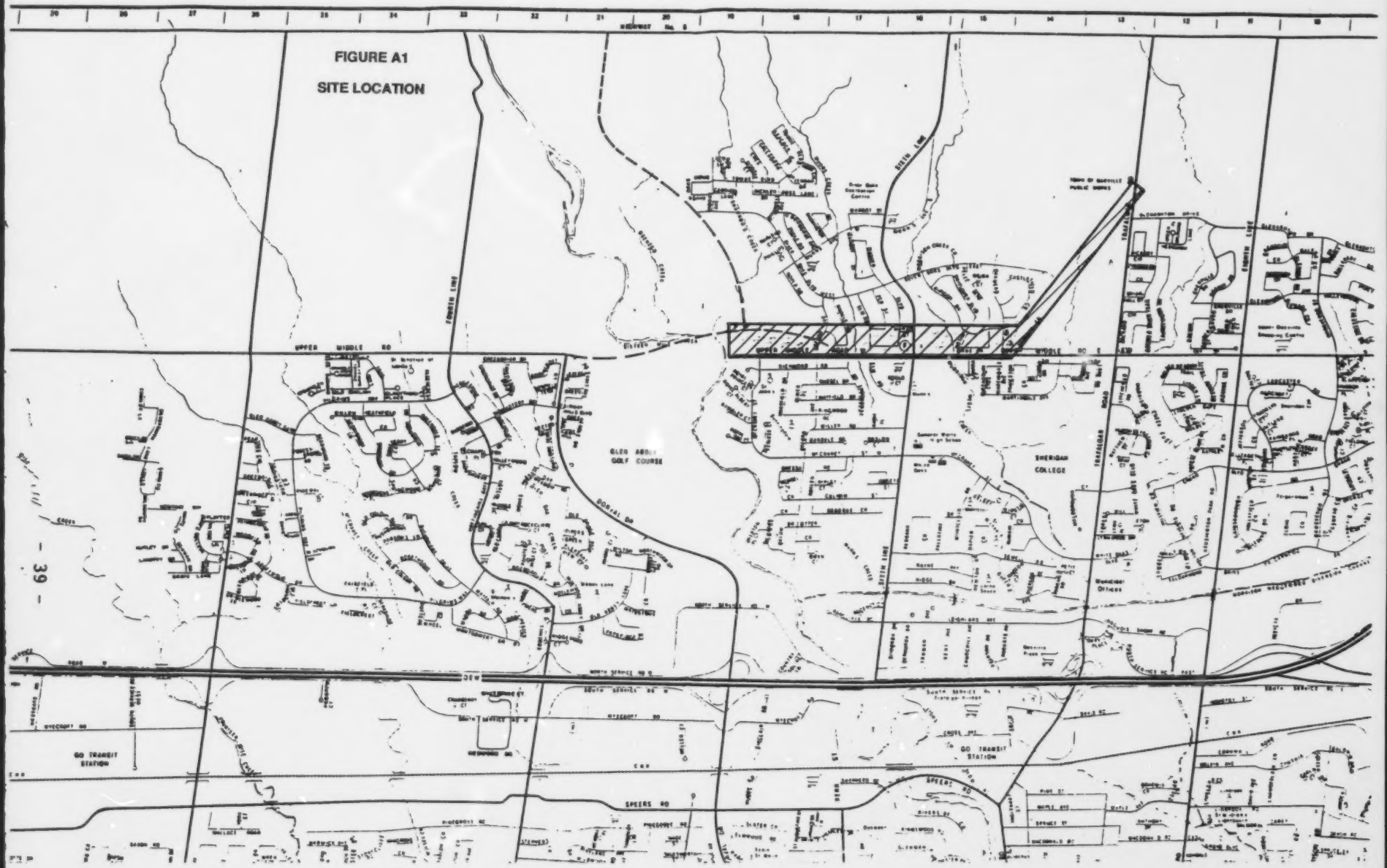
Figure A3 Site Location (Sketch JP-2)

Figure A4 Schematic of McGuigan-Type Tower (ST3-61)

Figure A5 Schematic of Grillage Foundation (Dwg No TD19830B00)

FIGURE A1

SITE LOCATION



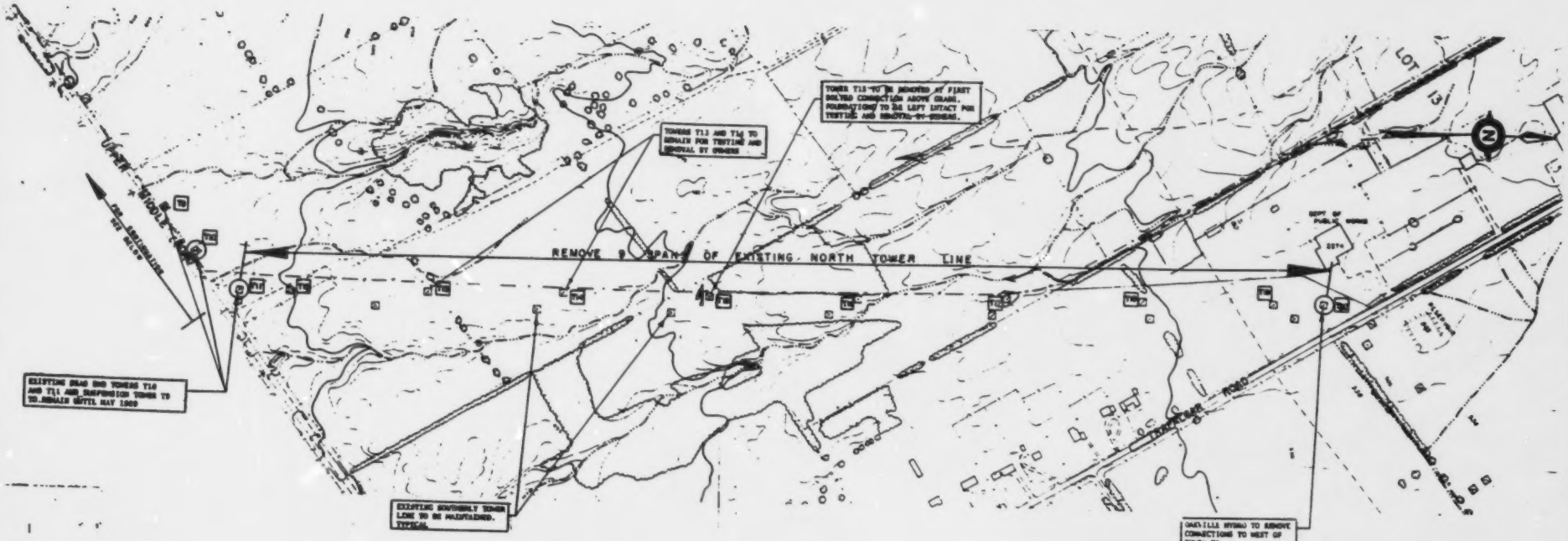

REMOVE 9 SPANS OF EXISTING NORTH TOWER LINE
LOT 13
TRAFALGAR ROAD
EXISTING SOUTHERLY TOWER LINE TO BE MAINTAINED. TYPICAL

FIGURE A2

HYDRO TOWER REMOVALS WITHIN EXCLUSIVE R.O.W. TO TRAFALGAR RD.)

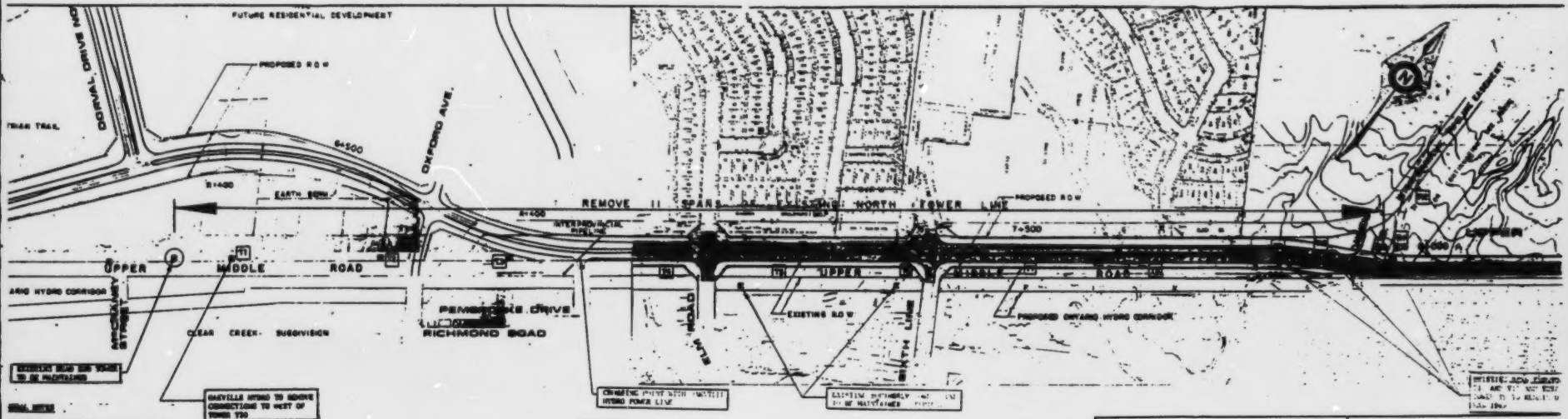


FIGURE A3

HYDRO TOWER REMOVALS PARALLEL TO UPPER MIDDLE ROAD

(OAKMEAD BLVD. TO WEST OF OXFORD AVE.)

SCALE 1: 2000

LEGEND

- EXISTING IN LINE (SUSPENSION) HYDRO TOWER
- EXISTING DEAD END HYDRO TOWER

TOWN OF OAKVILLE
DEPARTMENT OF PUBLIC WORKS

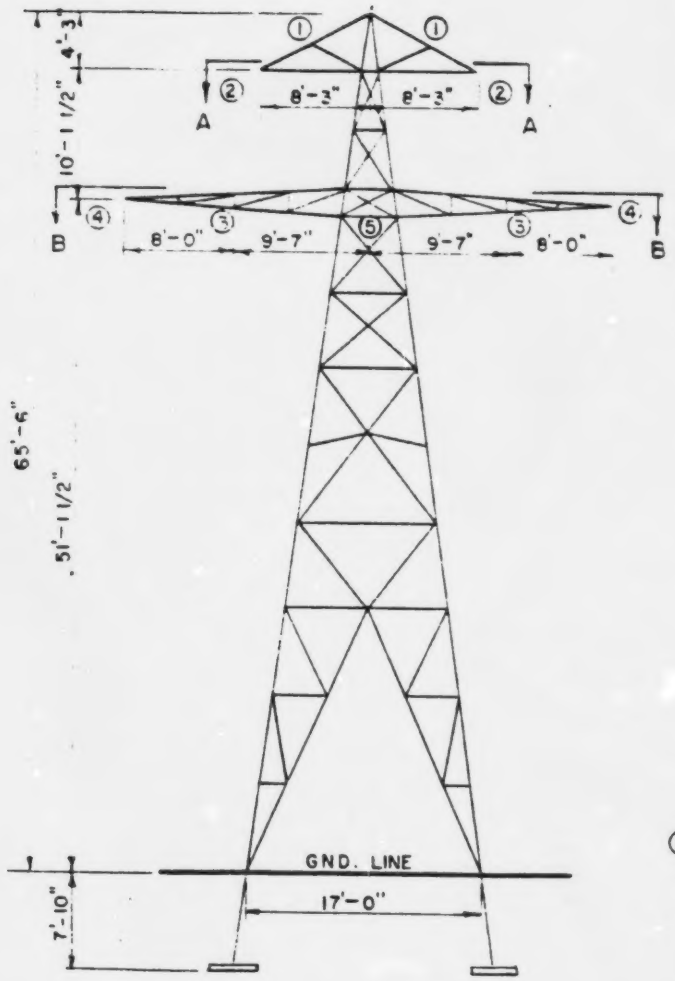
UPPER MIDDLE ROAD
HYDRO TOWER REMOVA
TRAFALGER RD. TO WEST OF OXFORD

C - 836 - 1

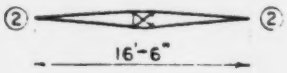
Sketch J

CONTRACT NO
C - 836

ST 3 - 61



SECTION "A"-"A"



SECTION "B"-"B"

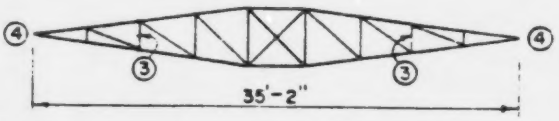


FIGURE A4

115 kv

DOUBLE CIRCUIT

McGUIGAN TYPE

SUSPENSION TOWER

APPROVED ..... TRANSMISSION ENGINEER ..... DEC. 1, 1959

ST 3 - 60

LOADS:

I VERTICALLY DOWNWARD

1000 LBS. AT POINTS (2), (2), (3), (3), (4) AND (4), AND 600 LBS. AT POINTS (1) AND (1)

II HORIZONTALLY, ~~PARALLEL~~ TRANSVERSE TO THE DIRECTION OF LINE

2500 LBS. AT ANY TWO POINTS (2), (2), (3), (3), (4) OR (4) APPLIED SIMULTANEOUSLY

III HORIZONTALLY, PARALLEL TO THE DIRECTION OF LINE

12,000 LBS. AT POINT (3) (LOWER CROSSARM CONNECTION)

IV WEIGHT OF STRUCTURE

LOAD COMBINATIONS:

(A) I, II AND IV

or (B) III AND IV

DATA:

CONDUCTOR SIZE 312,000 CM ACSR
CONDUCTOR MAX. TENSION 4200 LBS.
GROUND CABLE SIZE 5/16 IN. GALVANIZED STEEL
GROUND CABLE MAX. TENSION 2600 LBS.
NORMAL SPAN 550 FT.
MAX. DEFLECTION ANGLE WITH NORMAL SPAN
MAX. TANGENT SPAN
WEIGHT OF TOWER 3,917 LBS.
WEIGHT OF FOOTING (E) 690 LBS.
(R)

115 kv

DOUBLE CIRCUIT

McGUIGAN TYPE

SUSPENSION TOWER

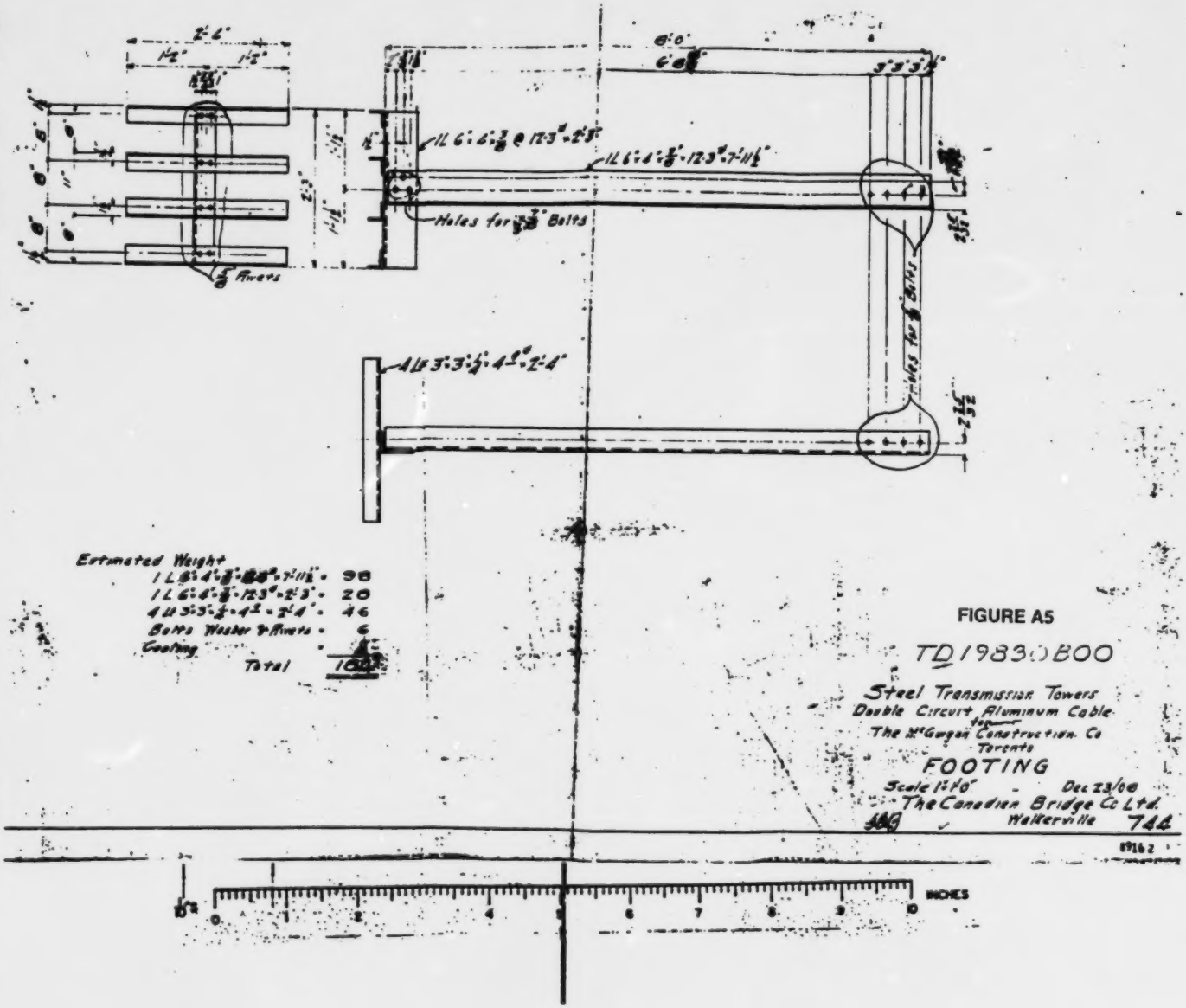


FIGURE A5

TD/1983/800

Steel Transmission Towers
Double Circuit Aluminum Cable
for
The McGregor Construction Co
Toronto

FOOTING

Scale 1:10' - Dec 23/08
The Canadian Bridge Co Ltd.
Walkerville

NAME & LINE PROPERTY DESIG NO.	PROP DESIG NO.	LINE SECTION OPER DESIG	CIRCUIT OPER DESIG	LINE LENGTH IN KM	STR REF	NO. OF STPS	CONDUCTOR, GROUND CABLE, HARDWARE INFORMATION AND GENERAL REMARKS	DATE PLACED IN SERVICE	PLAN AND PROFILE DRAWING NUMBERS
HALTON JCT T86 x PALERMO JCT T127 88754	78053 76680	NT60x63	K7B n K8B s	7.66	ST3-45	41T 37P	500 kcmil acsr (54/7) 5/16" st; (BB) South Line; NFH Part of former NT60x58	7/1922	PL 11881,11883,3721,3722 PR 11880,74398-5ET,11882
[redacted] 87877	78053 [redacted]	[redacted]	[redacted]	27.21	ST3-61	188T 1P	312 kcmil acsr 5/16" st; 12.12 km (75T) oper at 27.6 kV, NT86ST39 districts. Remainder idle	3/1911	PL [redacted] PR [redacted]
HAM-BEACH TS x HAM-GAGE TS 86263	03583 04903	NT17x24 -01	Q8TG8 Q9G n	2.40		U/G	1250 kcmil pilc=0.10 km 850 kcmil pilc oil-filled =2.30 km Canada Wire Co low-pressure underground cable are hollow conductor in ducts; formerly NT17x27 & NT27x24	9-1-51 11-8-51	PL 7805,7805A,7805B,7805C,8203,8252,11287,11614,11615,11615A,11856,11856A,11858,11858A,TD02602Z,71869ET,71870ET,71871ET,8128,11401-02,11829-29A-30-30A PR 7805,11614,11615,11856,11856A,11858,11858A,11401-02-03,11829-29A-30-30A
HAM-BEACH TS x HAM-GAGE TS 85884	03583 04903	NT17x24 -02	HL4 n B10 n HL3 s B11 s	2.59	ST4-83	16T, 8P	1192.5 kcmil acsr (54/19) VD 2-11/32" cwd; VD formerly NT17x77 and NT77x24; HL4ni, B10no HL3si, B11so	11-15-56	PL 11490,10138,97785-5ET PR 11491
HAM-BEACH TS x HAM-KENILWORTH TS 88936	03583 03723	NT17x27	H6K n H5K s	1.21		UG	1750 kcmil pipe type cable Const for 230 kV - oper at 115 kV	1-16-73	PL and PR 11856A (north route), 11858A (south route)
HAM-BIRMINGHAM TS x BURLINGTON STEEL CO 51573	09302 78232	NT50x92	HL3 s HL4 n	1.37	ST3-81	9T	605 kcmil acsr (54/7) =1.32 km 477 kcmil acsr (26/7)=0.05 km 7#10 awd; Part of former NT24x48; NT24x92; NT72x50	3-26-71	PL 3821,5051,11652,11762,11888,TD08332Z,TD12738Z PR 74225-3ET,3835,11652,4121,11889,11890,TD08333Z,TD16160Z
HAM-GAGE TS x HAM-BIRMINGHAM TS 21037	04903 09302	NT24x50	B10 HL4 HL3 B11	0.37		5T, 1P	1192.5 kcmil acsr, (54/19) VD 2-7#7 acs	5-11-76	PL & PR TD18389

APPENDIX B

Soil Investigation

OAKVILLE T. L. REFURBISHMENT

TOWER # 13

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 13 S.E. LEG A – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 7 Firm, Wet, Red–	2056	20.6										32	28	4
	Brown, clayey Silt with a trace of top soil.														
2	DEPTH – ft 1.5 – 3.0 N = 21 Very Stiff, Wet,	2194	15.0										30	26	4
	Red–Brown, clayey Silt with a trace of grey fine sandy silt														
	and the odd shale fragments.														
3	DEPTH – ft 3.0 – 4.5 N = 12 Stiff, Moist, Red–	2135	14.4						✓				31	26	5
	Brown, clayey Silt with a trace of fine shale fragments.														
4	DEPTH – ft 4.5 – 6.0 N = 12 Stiff, Moist, Red–	2145	16.2										28	20	8
	Brown, clayey Silt.														
5	DEPTH – ft 6.0 – 7.5 N = 31 Hard, Moist, Red–	2145	13.6						✓				26	21	5
	Brown clayey Silt with a trace of fine weathered shale														
	fragments.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 13 S.W. LEG B – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 8 Stiff, Dry, Red–	2091	11.3										28	22	6
	Brown, clayey Silt with a trace of shale fragments.														
2	DEPTH – ft 1.5 – 3.0 N = 23 Very Stiff, Moist,	2107	19.0										34	23	11
	Red–Brown, clayey Silt with a trace of fine gravel and the														
	odd root.														
3	DEPTH – ft 3.0 – 4.5 N = 28 Very Stiff, Moist, Red–	2309	16.5						✓				29	21	8
	Brown, clayey Silt (till–like).														
4	DEPTH – ft 4.5 – 6.0 N = 8 Stiff, Moist, Red–	2362	13.2										26	18	8
	Brown, clayey Silt with some weathered shale fragments.														
5	DEPTH – ft 6.0 – 7.5 N = 5 Firm, Dry, Red–Brown	2006	9.4						✓				25	18	7
	clayey Silt with a trace of shale fragments changing to red														
	shale at 7.0 .														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 13 N.W. LEG C – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 7 Firm, Wet, Red–	1821	28.9										29	24	5
	Brown, fissured clayey Silt with some fine grey sandy silt														
	pockets.														
2	DEPTH – ft 1.5 – 3.0 N = 17 Very Stiff, Moist,	2059	15.8										30	23	7
	Red–Brown, clayey Silt with a trace of fine shale fragments.														
3	DEPTH – ft 3.0 – 4.5 N = 10 Stiff, Moist, Red–	2026	15.1						✓				28	19	9
	Brown, fissured clayey Silt with fine grey sandy silt seams.														
4	DEPTH – ft 4.5 – 6.0 N = 8 Stiff, Moist, Red–	2147	12.0										25	19	6
	Brown, fissured clayey Silt with fine grey sandy silt seams.														
5	DEPTH – ft 6.0 – 7.5 N = 8 Stiff, Moist, Red–	2306	12.7						✓				29	21	8
	Brown, fissured clayey Silt with fine grey sandy silt seams.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 13 N.E. LEG D – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C kPa	φ DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 9 Stiff, Wet, Red–Brown, clayey Silt top soil with organics.	2075	21.5										41	25	16
2	DEPTH – ft 1.5 – 3.0 N = 9 Stiff, Wet, Red–Brown, clayey Silt with a trace of weathered shale fragments.	2032	26.8										30	24	6
3	DEPTH – ft 3.0 – 4.5 N = 5 Firm, Moist, Red– Brown, fissured clayey Silt with odd pockets of grey fine sandy silt.	2260	11.1						✓				31	22	9
4	DEPTH – ft 4.5 – 6.0 N = 4 Firm, Moist, Red– Brown, clayey Silt with a trace of weathered shale fragments.	2186	13.2										24	21	3
5	DEPTH – ft 6.0 – 7.5 N = 6 Stiff, Moist, Red– Brown, clayey Silt with a trace of shale fragments.	2245	12.5						✓				27	20	7

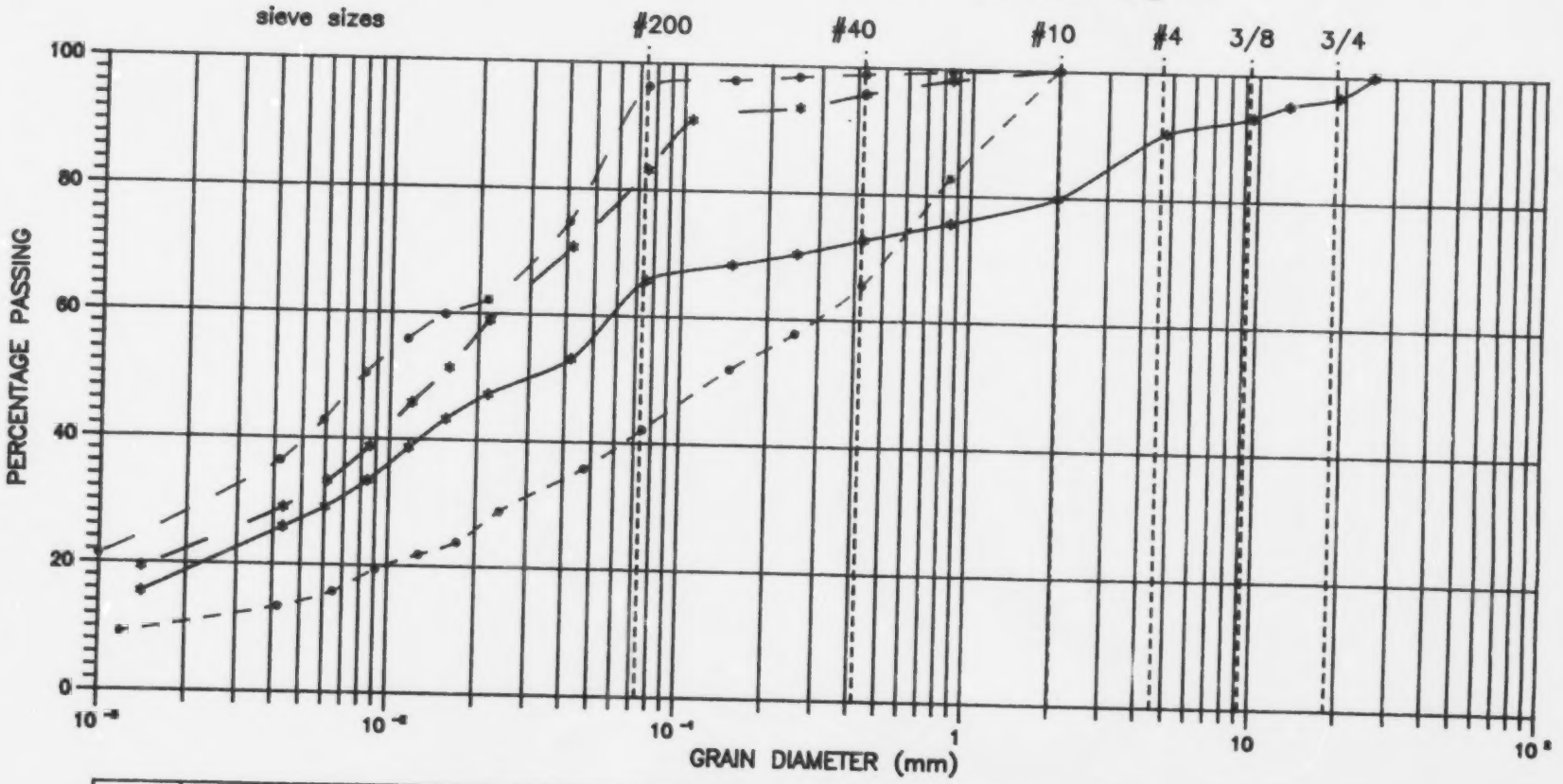
ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 13 NATIVE SOIL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/C	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH — ft 0.0 – 1.5 N = 11 Stiff, Wet, Red-Brown,	2048	21.1										36	30	6
	clayey Silt with some organics.														
2	DEPTH — ft 1.5 – 3.0 N = 80 Hard, Dry, Red-Brown,	2313	12.3										30	20	10
	fissured clayey Silt with a trace of fine grey sandy silt														
	pockets.														
3	DEPTH — ft 3.0 – 4.5 N = 96 Hard, Dry, Red-Brown,	2328	10.6						✓				27	20	7
	fissured clayey Silt and fine grey sandy Silt.														
4	DEPTH — ft 4.5 – 6.0 N = 60+ Hard, Dry, Red-Brown,	2344	7.7										29	21	8
	clayey Silt with a trace of fine sand.														
5	DEPTH — ft 6.0 – 6.3 N = 60+ Hard, Dry, Red-Brown,	—	7.6						✓				23	17	6
	clayey Silt (shale – like).														

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 13 SE Leg A

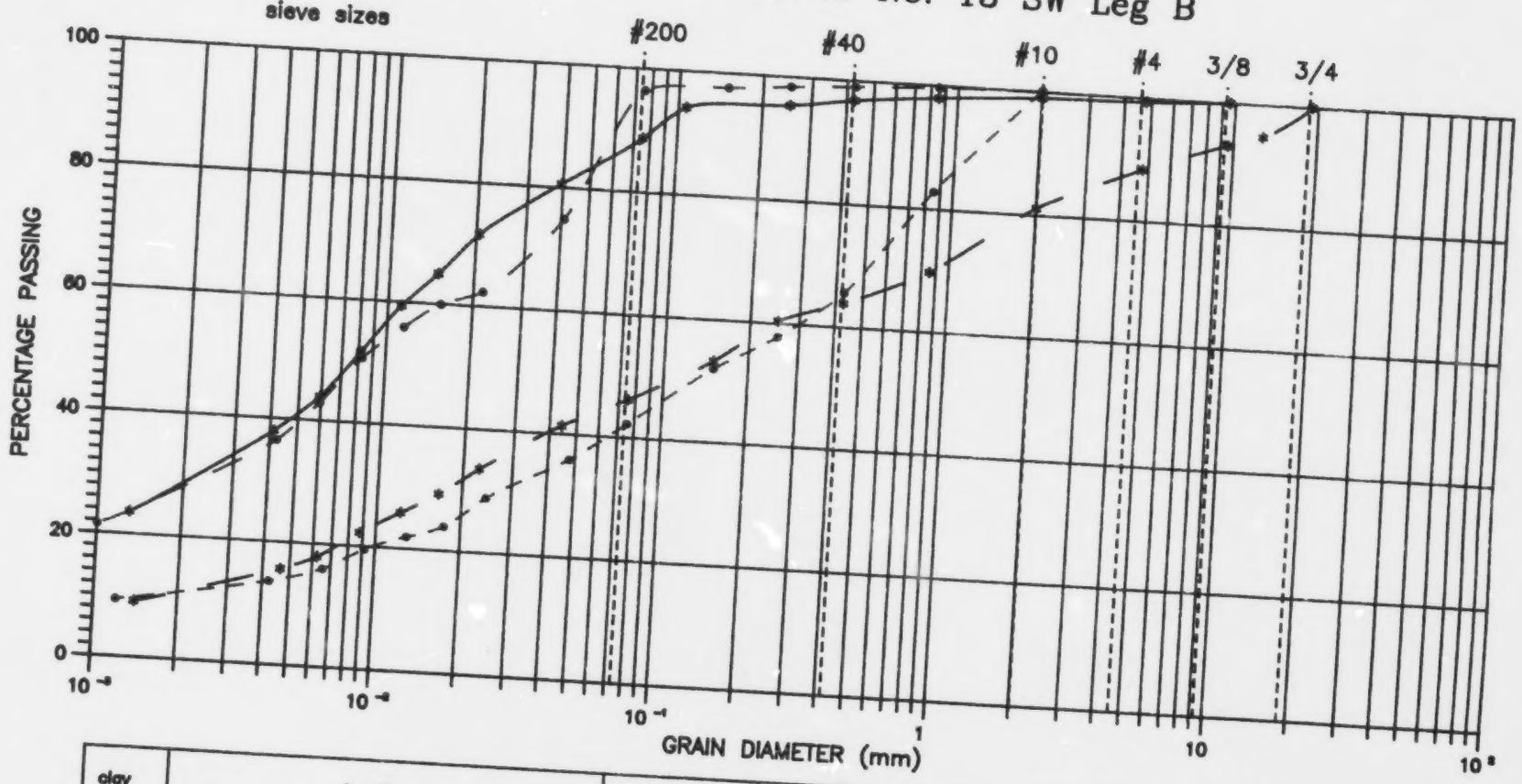


LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 6.3 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 13 SW Leg B



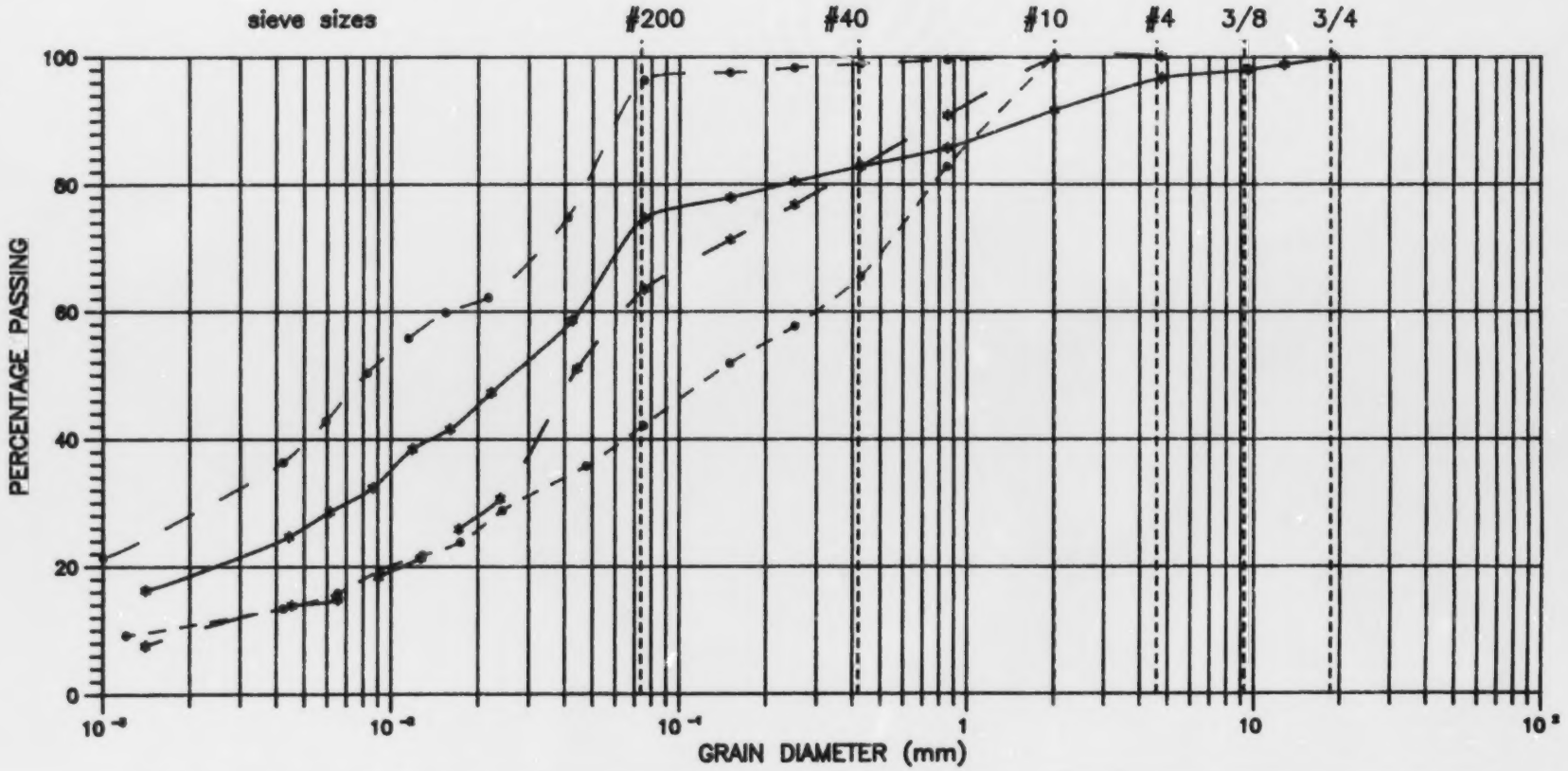
LEGEND

BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 6.3 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 13 NW Leg C



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

unified soil classification

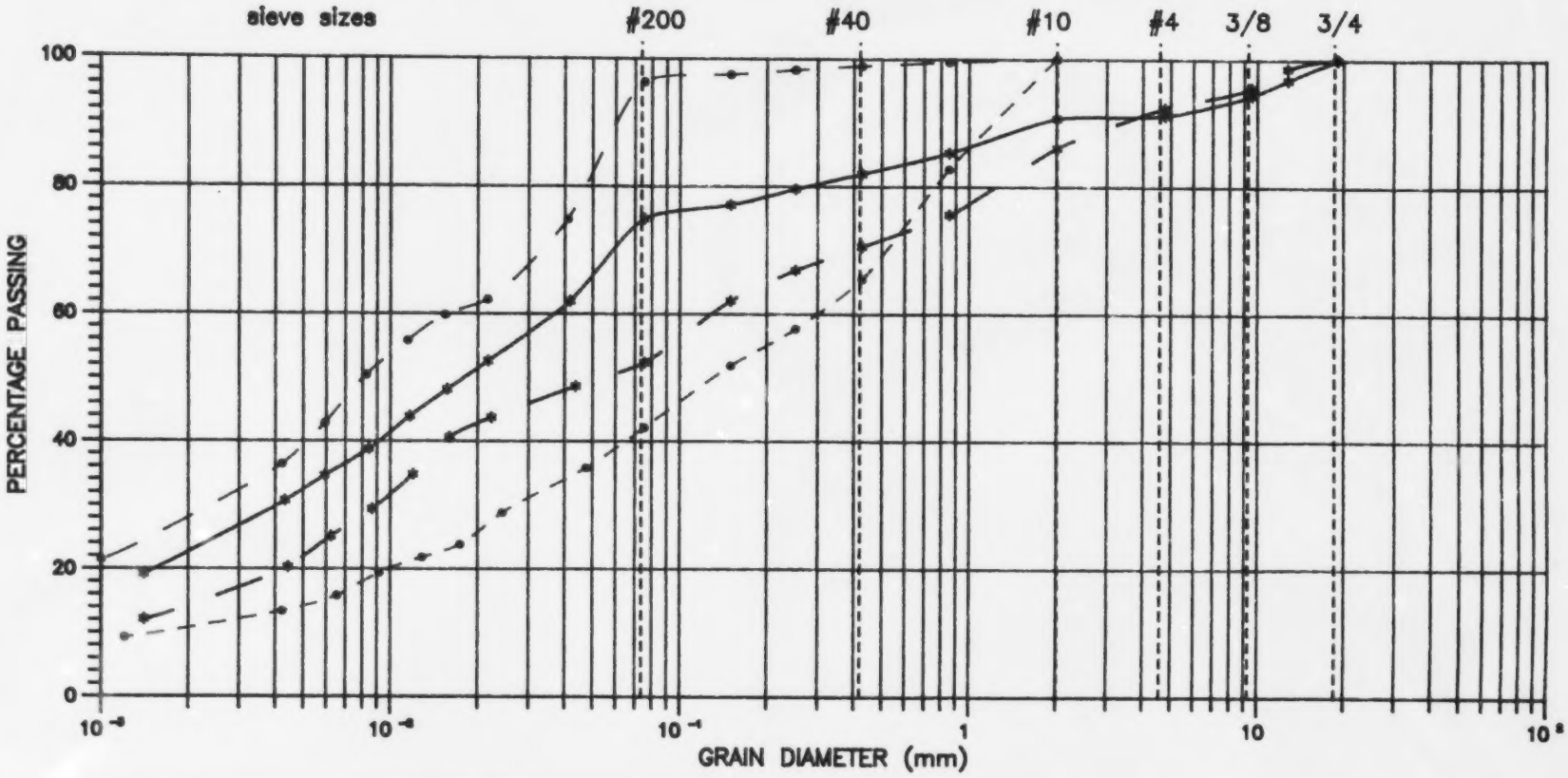
LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 6.3 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

89-139

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 13 NE Leg D



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

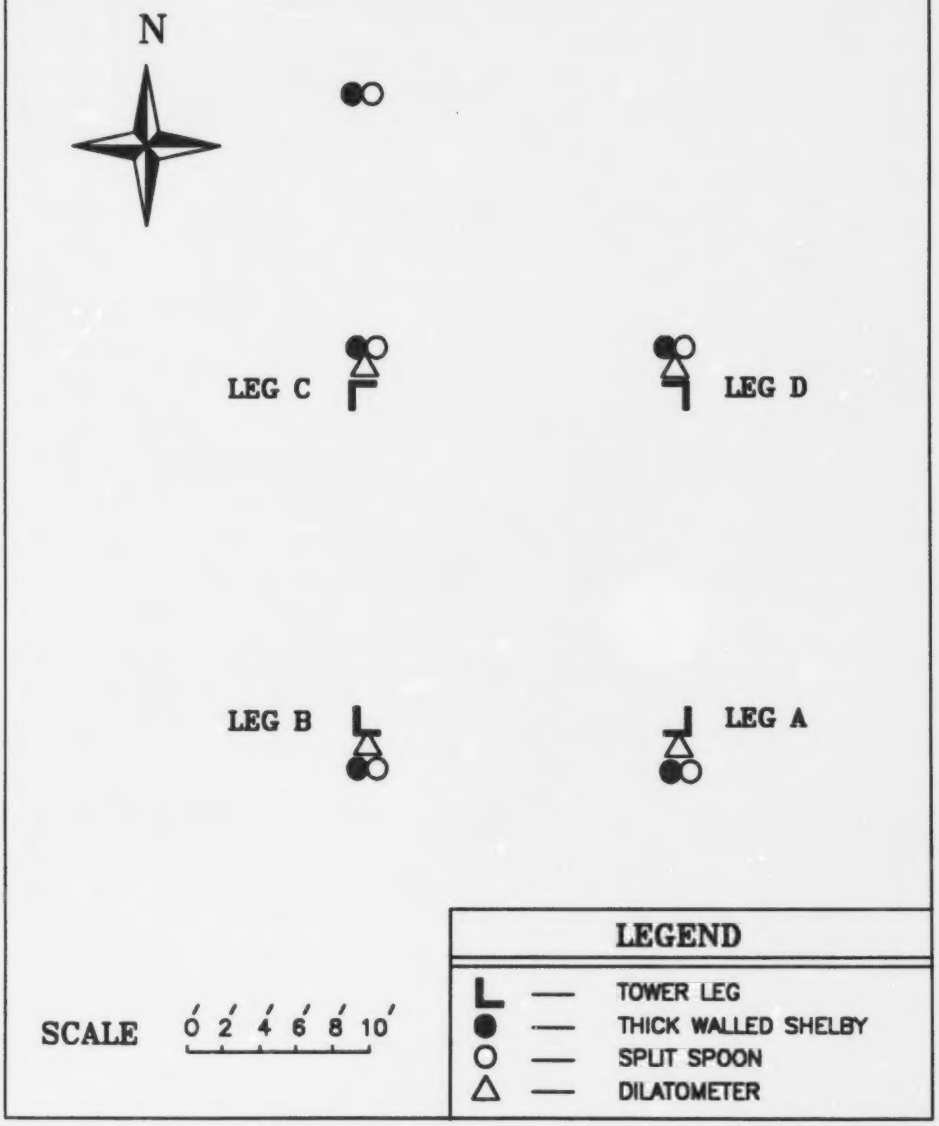
unified soil classification

LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 6.3 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

OAKVILLE T. L. REFURBISHMENT

TOWER # 14



ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 14 S.E. LEG A – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 9 Stiff, Wet, Brown,	2006	20.1										35	24	11
	clayey Silt with a trace of organics.														
2	DEPTH – ft 1.5 – 3.0 N = 8 Stiff, Moist, Red–	2113	20.6										28	23	5
	Brown, fissured clayey Silt with a trace of fine grey sandy														
	silt pockets.														
3	DEPTH – ft 3.0 – 4.5 N = 8 Stiff, Wet, Red–Brown,	2056	14.3						✓				29	21	8
	clayey Silt with some weathered shale fragments.														
4	DEPTH – ft 4.5 – 6.0 N = 7 Stiff, Wet, Red–Brown,	2129	17.9										23	20	3
	fissured clayey Silt with small pockets of grey silt.														
5	DEPTH – ft 6.0 – 7.5 N = 87 Hard, Moist, Red–	2309	11.9						✓				24	20	4
	Brown clayey Silt with the orld shale fragment.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 14 S.W. LEG B – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C kPa	φ DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 6 Firm, Moist, Red–	2205	18.2										33	23	10
	Brown, fissured clayey Silt with some shale and the odd														
	pocket of fine grey sandy silt.														
2	DEPTH – ft 1.5 – 3.0 N = 7 Firm, Wet, Red–Brown	3070	15.0										30	21	9
	clayey Silt with pockets of fine grey sandy silt.														
3	DEPTH – ft 3.0 – 4.5 N = 6 Firm, Moist, Red–	2223	14.9						✓				28	20	8
	Brown, fissured clayey Silt with a trace of grey sandy														
	silt pockets.														
4	DEPTH – ft 4.5 – 6.0 N = 5 Firm, Moist, Red–	2167	10.2										27	19	8
	Brown, fissured clayey Silt with a trace of grey sandy														
	silt pockets and the odd fine gravel.														
5	DEPTH – ft 6.0 – 7.5 N = 12 Stiff, Moist, Red–	2229	14.7						✓				23	19	4
	Brown clayey Silt with a trace of fine grey sandy silt														
	and the odd shale fragment.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 14 N.W. LEG C – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 9 Stiff, Moist, Brown,		23.6										37	29	8
	Silt (topsoil) with pockets of grey silt and few odd roots.														
2	DEPTH – ft 1.5 – 3.0 N = 14 Stiff, Moist, Red–	2186	16.2										35	24	11
	Brown, fissured clayey Silt with some pockets of fine														
	grey sandy silt.														
3	DEPTH – ft 3.0 – 4.5 N = 8 Stiff, Moist, Red–	2200	15.4						✓				31	23	8
	Brown, fissured clayey Silt with some pockets of														
	fine grey sandy silt.														
4	DEPTH – ft 4.5 – 6.0 N = 16 Very Stiff, Red–	2090	16.4										24	18	6
	Brown, fissured clayey Silt with some pockets of sandy silt														
	and the odd fine gravel.														
5	DEPTH – ft 6.0 – 7.5 N = 76 Hard, Dry, Red–Brown		7.3						✓				23	17	6
	clayey silt with a trace of pockets of grey silt.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 14 N.E. LEG D – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 6 Stiff, Wet, Red–Brown	2065	20.9										24	19	5
	clayey Silt topsoil with organics and fine gravel.														
2	DEPTH – ft 1.5 – 3.0 N = 7 Stiff, Wet, Red–Brown,	2125	15.7										33	20	13
	clayey Silt with traces of fine grey sand and weathered														
	shale fragments.														
3	DEPTH – ft 3.0 – 4.5 N = 6 Stiff, Moist, Red–	2129	16.4						✓				28	20	8
	Brown, fissured clayey Silt with some fine grey sandy Silt														
	pockets.														
4	DEPTH – ft 4.5 – 6.0 N = 6 Stiff, Dry, Red–	2141	9.9										26	20	6
	Brown, clayey Silt with a trace of shale fragments.														
5	DEPTH – ft 6.0 – 7.5 N = 12 Very Stiff, Moist, Red–	2058	9.2						✓				23	20	3
	Brown, clayey Silt with a trace of shale fragments.														

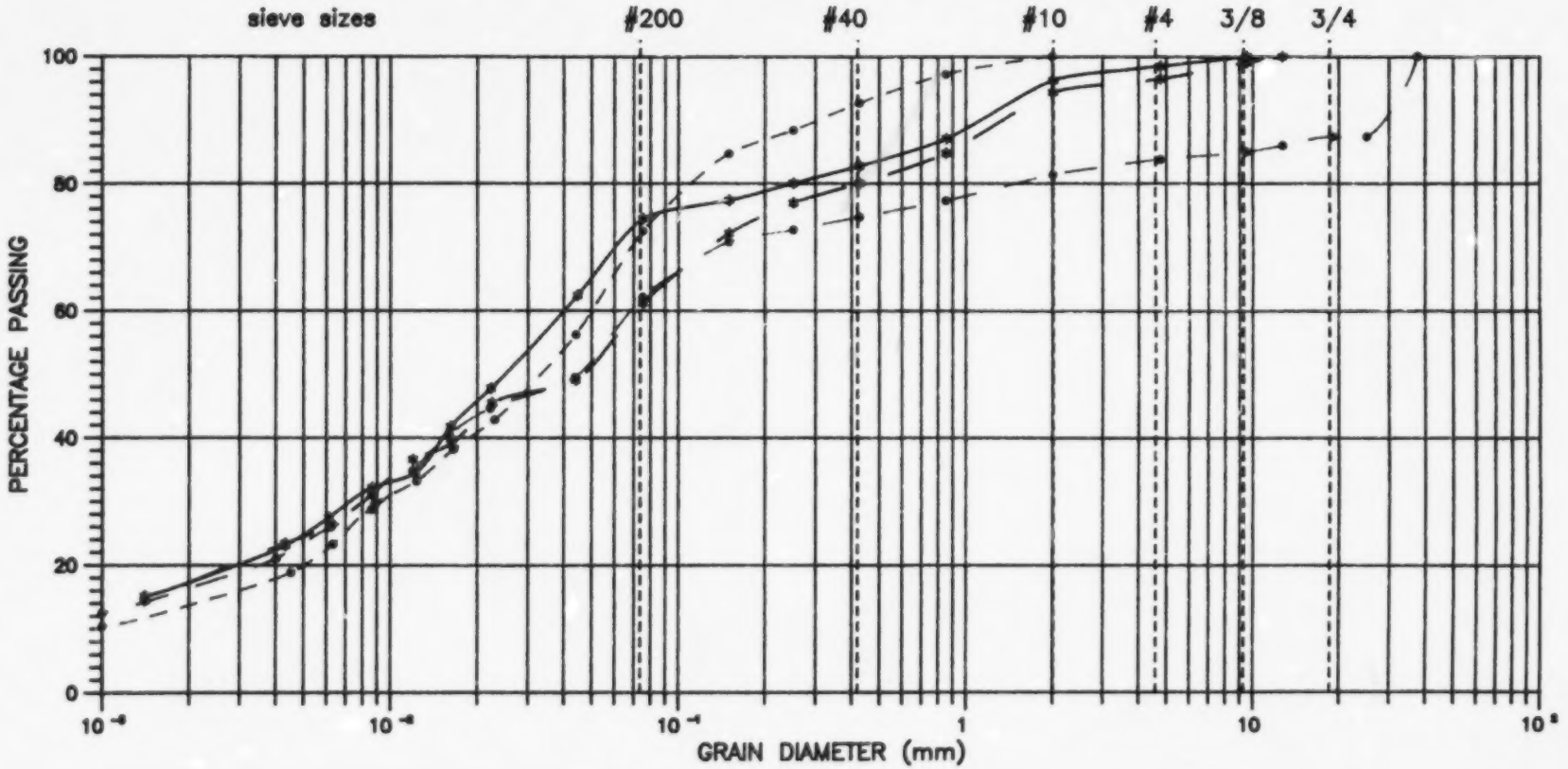
ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 14 NATIVE SOIL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 8 Stiff, Wet, Brown,		28.3										38	19	19
	clayey Silt (topsoil).														
2	DEPTH – ft 1.5 – 3.0 N = 64 Hard, Dry, Red–Brown,	2187	13.9										37	27	10
	clayey Silt (till–like) with odd pockets of fine grey sandy silt.														
3	DEPTH – ft 3.0 – 4.5 N = 116+ Hard, Dry, Red–Brown,	2369	9.1						✓				26	20	6
	clayey Silt with some grey shale fragments.														
4	DEPTH – ft 4.5 – 6.0 N = 100+ Hard, Dry, Red–Brown,	2287	10.4										30	18	12
	fissured clayey Silt with a trace of fine gravel and shale														
	fragments.														
5	DEPTH – ft 6.0 – 7.5 N = 116+ Hard, Dry, Red–Brown	2452	8.2						✓				24	19	5
	clayey Silt with a trace of fine sand pockets.														

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 14 SE Leg A



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

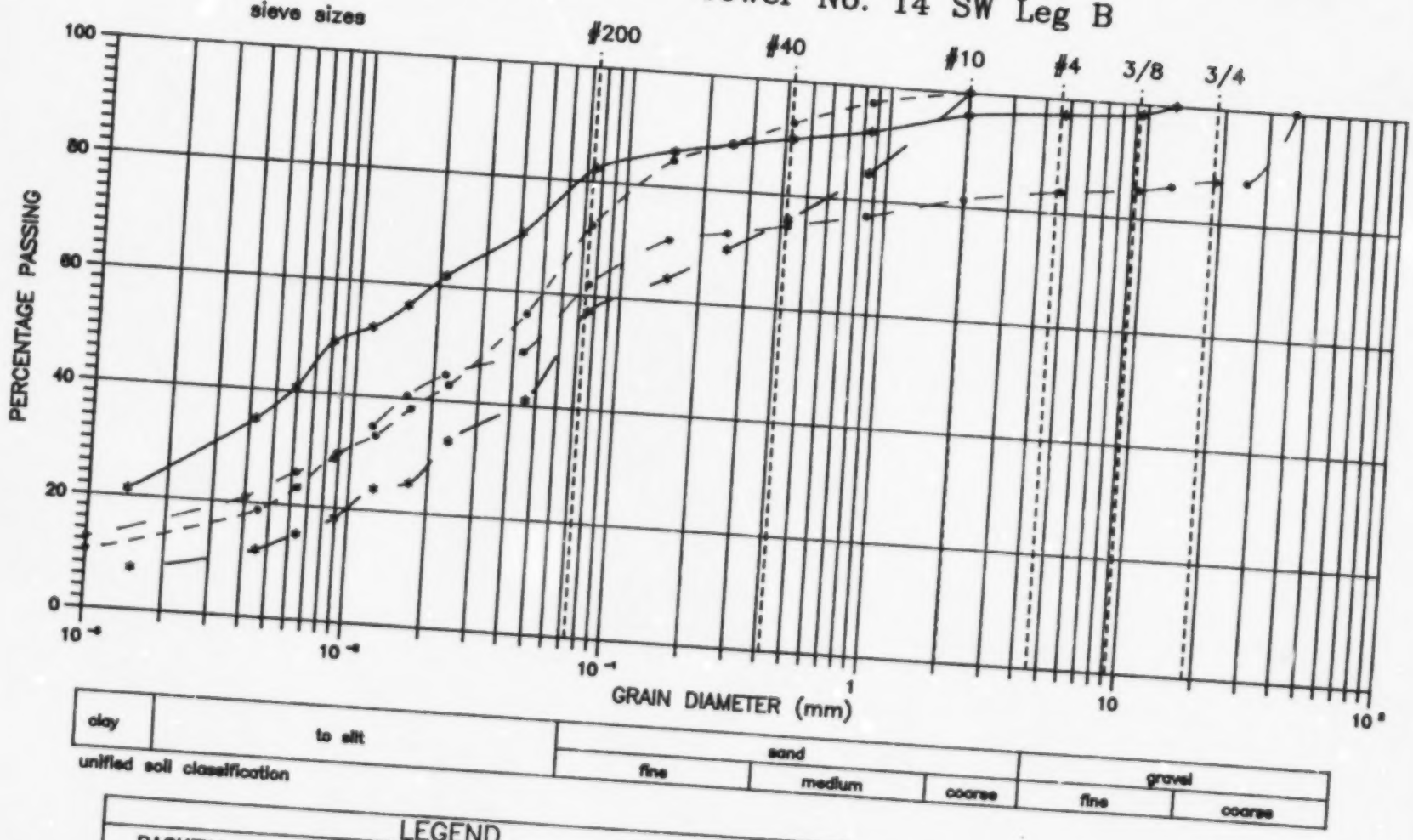
unified soil classification

LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS

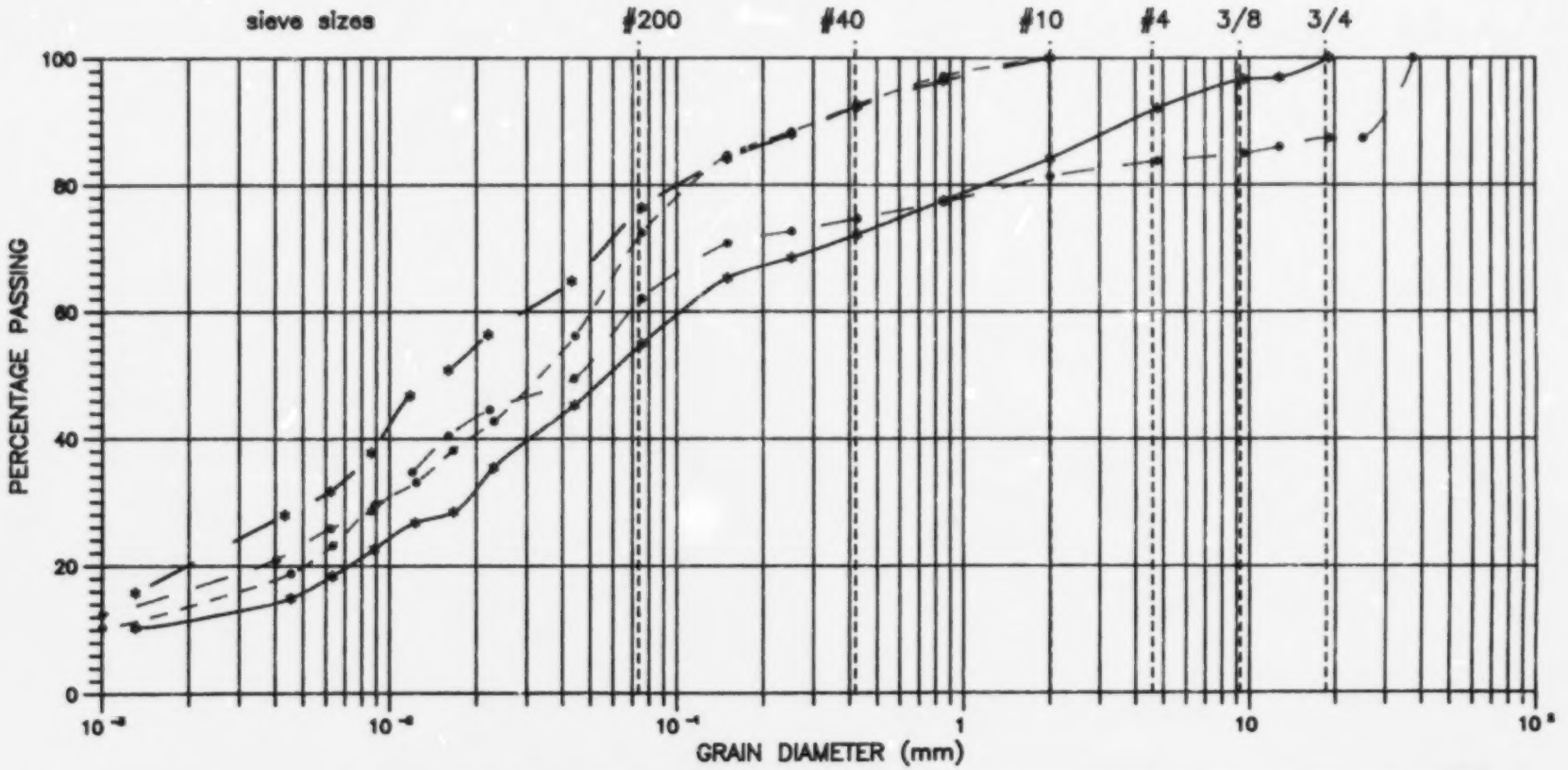
Oakville T. L. – Tower No. 14 SW Leg B



ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 14 NW Leg C



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

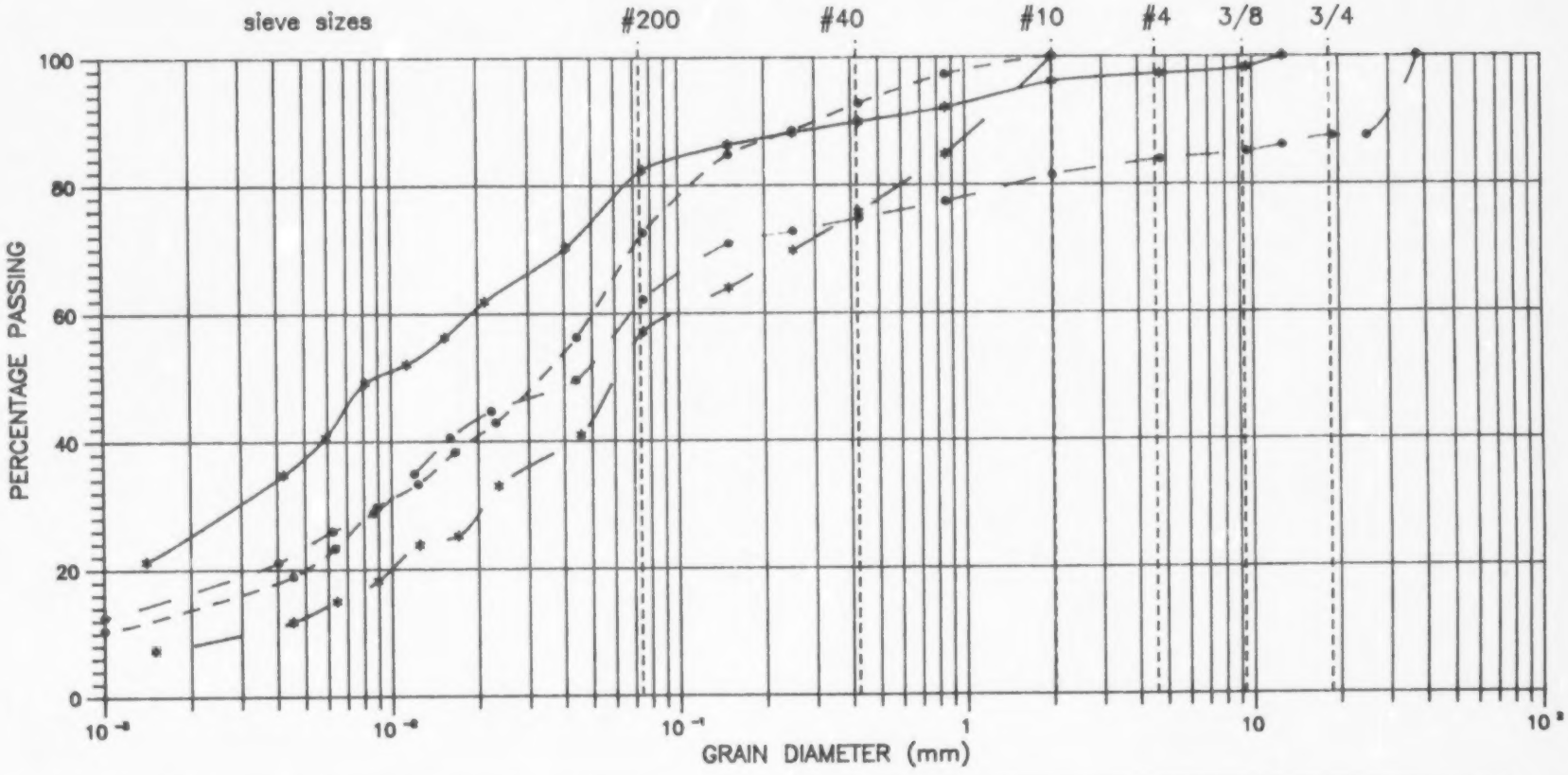
unified soil classification

LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 14 NE Leg D



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

unified soil classification

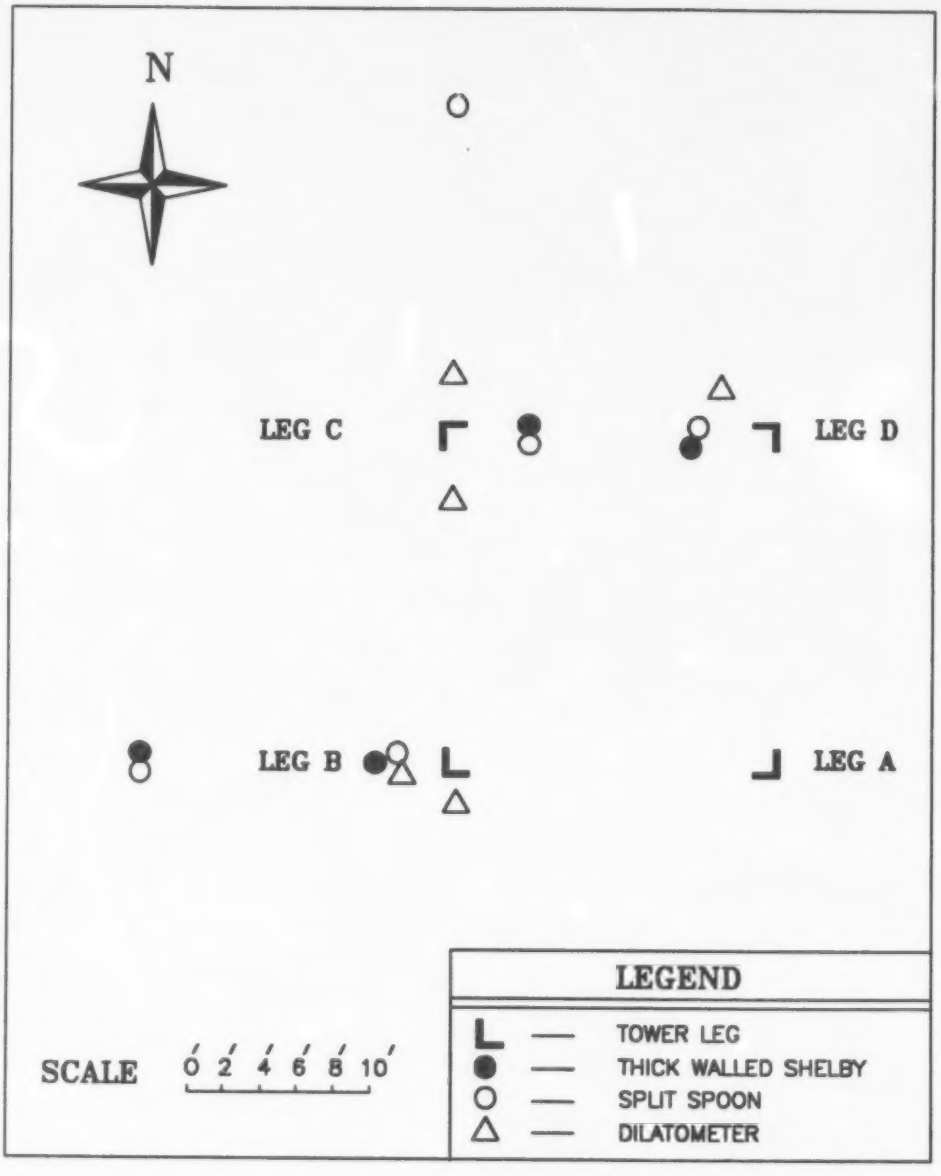
LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

89-139

OAKVILLE T. L. REFURBISHMENT

TOWER # 15



ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 15 S. E. LEG A – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. p.c.f.	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 2.0 Wet, Red–Brown,		25.1										49	25	24
	clayey Silt with some organics and the odd root.														
2	DEPTH – ft 4.0 Moist, Red–Brown,		9.1						✓				30	24	6
	clayey Silt with some weathered shale fragments.														
3	DEPTH – ft 7.0 Wet, Red–Brown,		15.1						✓	14.2	115.2		30	21	9
	clayey Silt with some weathered shale fragments.														
	DEPTH – ft														
	DEPTH – ft														

NOTE : Disturbed soil samples obtained after footing excavation.

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 15 S.W. LEG B – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C kPa	φ DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 1.5 N = 4 Soft, Wet, Red–	2107	20.9										45	34	11
	Brown, clayey Silt with some organics and a trace of fine														
	grey sandy silt.														
2	DEPTH – ft 1.5 3.0 N = 6 Firm, Wet, Red–	2035	23.6										35	23	12
	Brown, fissured clayey Silt with a trace of fine grey sandy														
	silt pockets.														
3	DEPTH – ft 3.0 4.5 N = 13 Stiff, Moist, Red–	2229	16.2						✓				41	26	15
	Brown, clayey Silt with odd pockets of fine grey sandy														
	silt.														
4	DEPTH – ft 4.5 6.0 N = 13 Stiff, Moist, Red–	2122	19.4										25	20	5
	Brown, clayey Silt with the odd fine shale fragments.														
5	DEPTH – ft 6.0 7.5 N = 29 Very Stiff, Moist,	2210	17.6						✓				32	21	11
	Red–Brown, clayey Silt with odd pockets of fine grey sandy														
	silt.														

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 15 N.W. LEG C – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.88 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	STD PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 6 Firm, Wet, Dark	1785	37.1										51	33	18
	Brown, clayey Silt with some organics and a trace of fine														
	gravel (topsoil).														
2	DEPTH – ft 1.5 – 3.0 N = 24 Very Stiff, Moist,	2203	13.9										30	21	9
	Red–Brown, clayey Silt with a trace of grey silt.														
3	DEPTH – ft 3.0 – 4.5 N = 37 Hard, Moist, Red–	2295	11.9						✓				28	20	8
	Brown, clayey Silt with a trace of organics.														
4	DEPTH – ft 4.5 – 6.0 N = 82 Hard, Dry, Red–	2247	9.6										26	20	6
	Brown, clayey Silt.														
5	DEPTH – ft 6.0 – 7.5 N = 124 Hard, Dry, Red–	2403	9.3						✓				29	21	8
	Brown, clayey Silt with a trace of weathered shale														
	particles.														

NOTE : Additional carton samples were obtained for moisture content measurements. (see Figure 22 and Table B1)

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 15 N.E. LEG D – BACKFILL MATERIAL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 4 Soft, Wet, Red–	2191	20.7										34	22	12
	Brown, clayey Silt (topsoil) with traces of roots and grass.														
2	DEPTH – ft 1.5 – 3.0 N = 27 Very Stiff, Moist,	2292	11.8										29	22	7
	Red–Brown, clayey Silt.														
	shale fragments.														
3	DEPTH – ft 3.0 – 4.5 N = 93 Hard, Dry, Red–	2421	9.8						✓				25	21	4
	Brown, clayey Silt (shale–like)														
4	DEPTH – ft 6.0 – 7.5 N = 60 Hard, Dry, Red–	2355	10.8						✓				30	23	7
	Brown, clayey Silt.														
	DEPTH – ft														

NOTE : Additional carton samples were obtained for moisture content measurements. (see Figure 22 and Table B1)

ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
1	OAKVILLE TL	TOWER # 15 NATIVE SOIL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m³ (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m³	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 18 Very Stiff, Wet,		51.5										44	34	10
	Red–Brown, clayey Silt with some organics and a trace of														
	fine gravel.														
2	DEPTH – ft 1.5 – 3.0 N = 43 Hard, Moist, Red–	2004	22.1										30	21	9
	Brown, fissured clayey Silt with a trace of medium to														
	fine gravel (till–like).														
3	DEPTH – ft 3.0 – 4.5 N = 81 Hard, Moist, Brown–	2843	10.2						✓				27	20	7
	Red, clayey Silt with a trace of fine grey sandy silt.														
4	DEPTH – ft 4.5 – 5.5 N = 114 Hard, Dry, Brown–	2532	10.1										28	21	7
	Red, clayey Silt (weathered shale–like).														
5	DEPTH – ft 6.0 – 7.0 N = 134 Hard, Dry, Brown–	2327	8.0						✓				32	23	9
	Red, clayey Silt with a trace of fine shale fragments.														

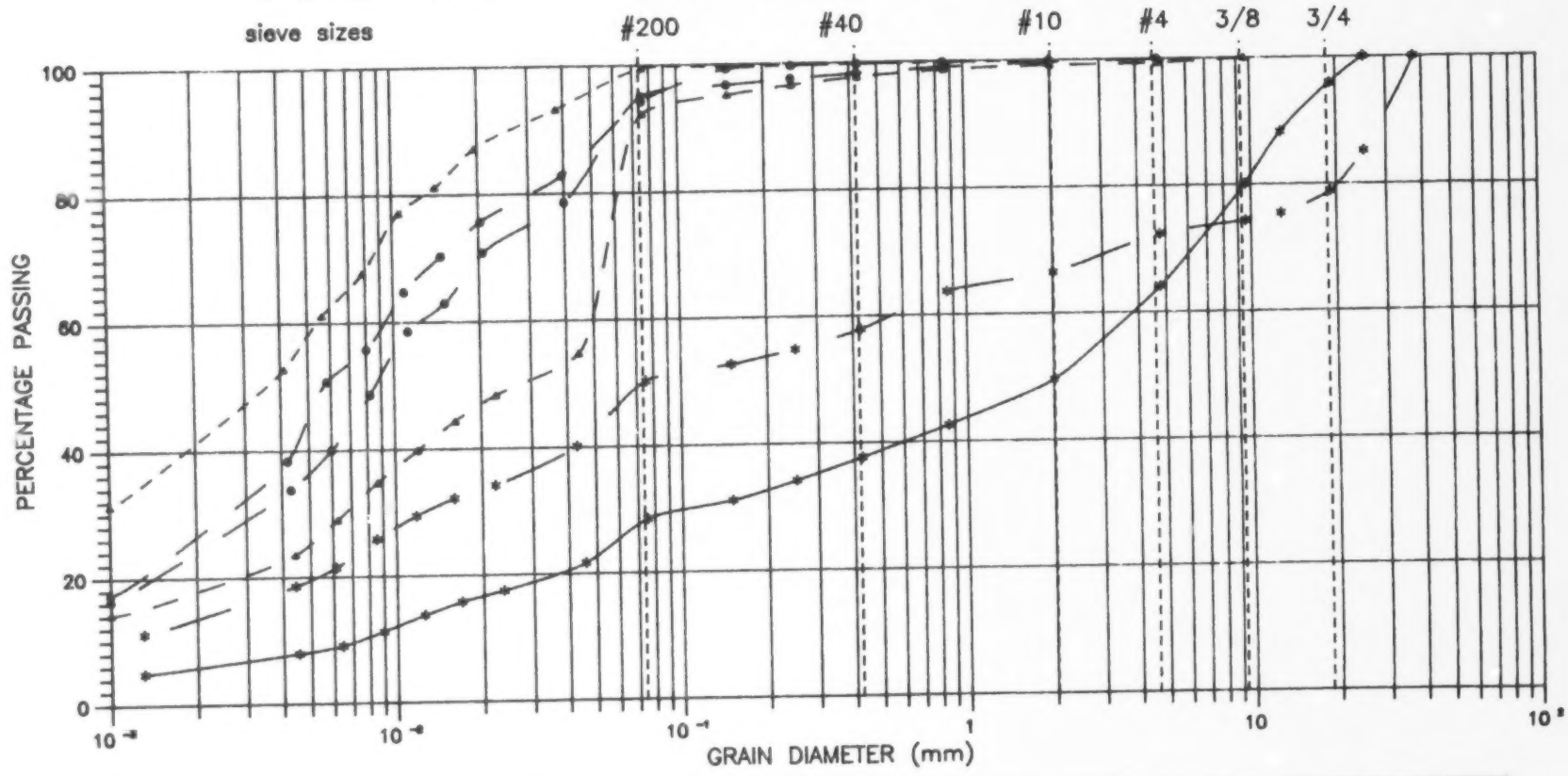
ONTARIO HYDRO
RESEARCH DIVISION

HOLE No.	PROJECT — REFURBISHMENT	REMARKS
3	OAKVILLE TL	TOWER # 15 NATIVE SOIL

SAMP. No.	LABORATORY SOIL CLASSIFICATION	NAT. DENS. kg/m^3 (x.062 =PCF)	NAT. M.C. % DRY WT.	SHEAR STRENGTH kPa (x20.89 = PSF) U/C	Q/U	C/U	SHEAR STRENGTH PARAMETERS C' kPa	φ' DEG.	PART. SIZE ANAL.	ST'D PROCTOR OPT. M/C	MAX. DENS. kg/m^3	PERM. cm/sec at 20°C	ATTERBERG LIMITS L. L.	P. L.	P. I.
1	DEPTH – ft 0.0 – 1.5 N = 7 Firm, Wet, Red–		56.8										57	39	18
	Brown, clayey Silt with some organics.														
2	DEPTH – ft 1.5 – 3.0 N = 23 Very Stiff, Moist,	2297	12.7										38	23	15
	Red–Brown, fissured clayey Silt with the odd pocket														
	of fine grey sand.														
3	DEPTH – ft 3.0 – 4.5 N = 47 Hard, Moist, Brown–	2329	13.3						✓				26	19	7
	Red, silty Clay with a trace of fine grey sandy silt.														
4	DEPTH – ft 4.5 – 5.4 N = 60+ Hard, Dry, Brown–	2437	8.4										26	21	5
	Red, fissured clayey Silt with small pockets of fine grey														
	sand.														
5	DEPTH – ft 6.0 – 7.0 N = 77 Hard, Dry, Brown–	2320	9.7						✓				33	23	10
	Red, clayey Silt.														

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 15 SE Leg A



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

unified soil classification

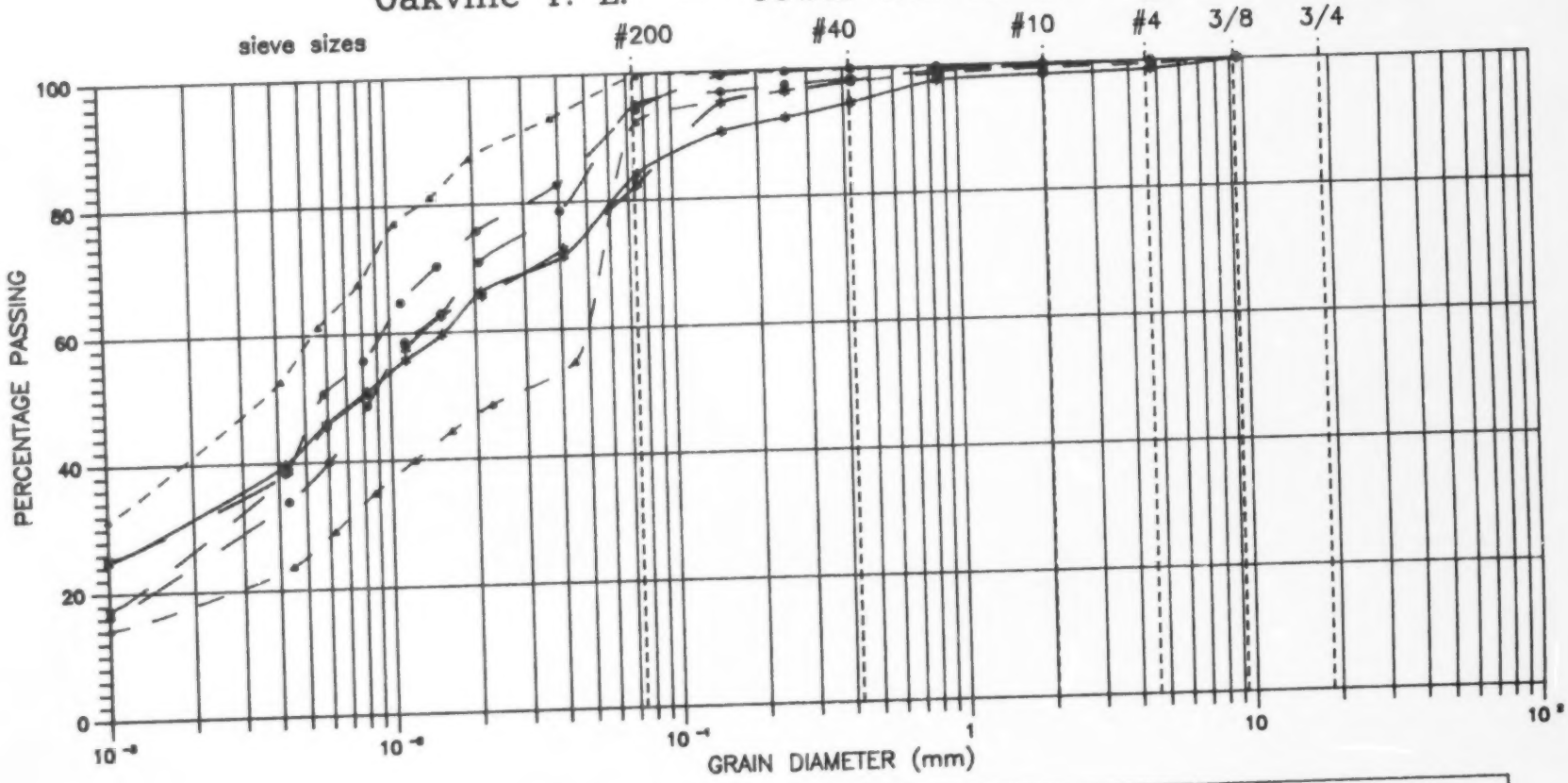
LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL (BH–1)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–
NATIVE SOIL (BH–3)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–

ONTARIO HYDRO
RESEARCH DIVISION

89-139

MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 15 SW Leg B



LEGEND

BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL (BH–1)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–
NATIVE SOIL (BH–3)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–

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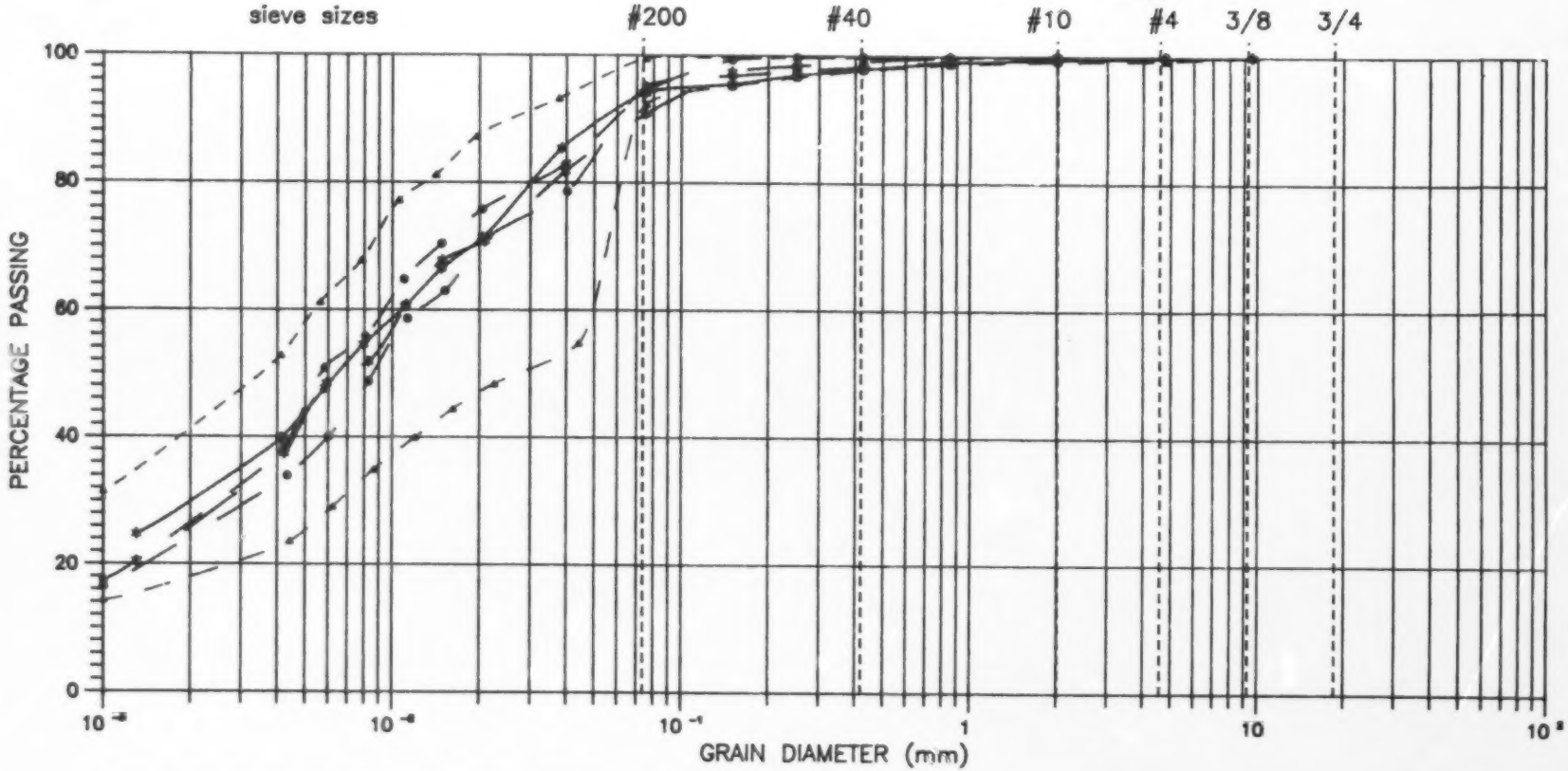
MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 15 NW Leg C



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

unified soil classification

LEGEND		
BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL (BH–1)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–
NATIVE SOIL (BH–3)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–

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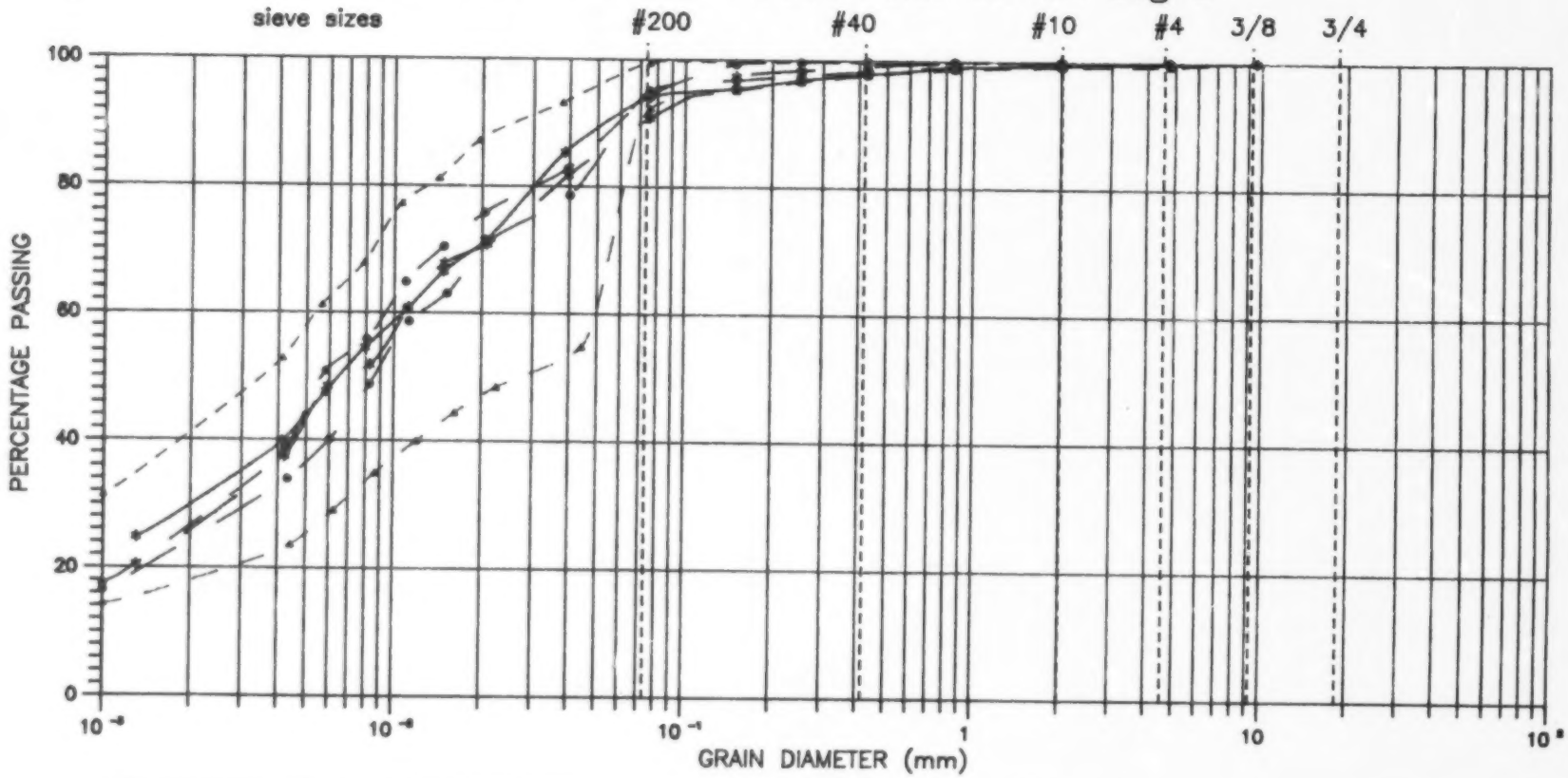
MECHANICAL ANALYSIS

Oakville T. L. – Tower No. 15 NE Leg D



clay	to silt	sand			gravel	
		fine	medium	coarse	fine	coarse

unified soil classification

LEGEND

BACKFILL	(3.0 – 4.5 m)	–
	(6.0 – 7.5 m)	–
NATIVE SOIL (BH–1)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–
NATIVE SOIL (BH–3)	(3.0 – 4.5 m)	–
	(6.0 – 7.0 m)	–

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89-139

TABLE B1

Moisture Content Measurements of Backfill Material at Tower No. 15

LEG No.	MOISTURE CONTENT (%) *	
	FROM 2 ft. DEPTH	FROM 7 ft. DEPTH
LEG A (SE)	24.8	14.0
LEG B (SW)	23.7	13.5
LEG C (NW)	26.5	21.9
LEG D (NE)	23.1	20.6

* Additional carton samples were obtained during footing excavations.

APPENDIX C

Field Load Tests

TABLE C1 RESULTS OF FIELD LOAD TESTING OF GRILLAGES

TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. B (NORTHWEST LEG) JAN. /89
TOWER NO. 15
GROUNDLINE SHEAR LOAD TEST

LOAD (kN)	GROUNDLINE DEFLECTIONS (mm)	HOLD TIME (MIN.)
0.00	0.00	0
8.90	15.24	
13.34	28.73	
17.79	44.09	
16.01	44.96	2
15.57	45.42	5
15.57	45.42	
22.24	73.48	
20.02	74.55	2
19.57	74.98	5
19.13	75.13	6
26.69	75.13	
22.24	116.21	
24.46	120.14	2
24.46	120.14	
23.35	120.32	3
23.35	120.65	5
22.24	120.70	7
28.91	135.13	8
30.02	163.07	9
30.02	163.07	
31.14	171.96	
31.14	187.71	1
31.14	193.29	2
31.14	200.15	3
31.14	206.88	4
31.14	209.80	6
31.14	209.80	
31.14	211.25	7
31.14	212.73	8
31.14	214.33	9
31.14	215.72	10
31.14	220.32	15
31.14	220.32	
33.36	226.54	17
34.47	236.70	18
34.47	242.54	19
34.47	247.37	20
34.25	252.96	21
34.25	252.96	
33.36	256.13	22
37.81	277.09	

TABLE C1 RESULTS OF FIELD LOAD TESTING OF GRILLAGES
(Cont'd)
TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. B (NORTHWEST LEG) JAN. /89
TOWER NO. 15
GROUNDLINE SHEAR LOAD TEST

LOAD (kN)	GROUNDLINE DEFLECTIONS (mm)	HOLD TIME (MIN.)
37.81	284.71	1
38.92	294.87	2
39.14	301.22	
39.14	301.22	
39.14	307.57	3
39.14	312.65	4
39.14	**	

NOTE: (*) APPLIED LOAD AT 0.31 m (13") ABOVE GROUNDLINE ON STUB LEG
APPLIED LOAD AT SLIGHT INCLINED ANGLE OF 1 DEGREE WITH RESPECT TO HORIZONTAL

(**) DISPLACEMENT TRANSDUCER SLIPPED OFF FOOTING

(+) SLIGHT FLUCTUATIONS IN THE APPLIED LOAD DURING HOLDS

TABLE C2 RESULTS OF FIELD LOAD TESTING OF GRILLAGES

TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. C (NORTHWEST LEG) JAN. /89
TOWER NO. 15
UPLIFT LOAD TEST

HOLD TIME (MIN.)	LOAD (kN)	FOOTING DEFLN (mm)	VERTICAL TELL-TALES * T1 (mm)	T2 (mm)	T3 (mm)	T4 (mm)	T5 (mm)	T6 (mm)	T7 (mm)	T8 (mm)
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	22.25	2.29	0.05	0.08	0.03	0.00	0.13	0.10	-0.03	-0.10
	44.50	4.72	0.00	0.00	0.03	0.03	0.30	0.13	-0.15	-0.41
	66.75	8.61	0.13	0.18	0.08	0.13	0.89	0.51	0.05	0.13
	89.00	16.66	0.10	0.18	0.08	0.23	2.16	1.07	-0.05	0.05
5	89.00	21.39	0.20	0.25	0.18	0.38	3.43	1.57	0.00	-0.15
10	89.00	23.22	0.33	0.43	0.41	0.64	4.01	1.88	0.03	0.15
	111.25	30.15	0.36	0.43	0.38	0.71	6.05	2.92	0.25	0.15
5	111.25	40.44	0.28	0.30	0.18	0.64	8.03	3.40	-0.15	-0.08
7	111.25	43.84	0.18	0.23	0.13	0.61	9.04	3.86	-0.23	0.00
10	111.25	45.62	0.20	0.30	0.20	0.71	8.69	4.17	-0.13	0.13
11	111.25	47.57								
RESET	111.25	47.57								
15	111.25	48.44	0.38	0.53	0.46	1.04	10.79	4.75	0.36	-0.41
20	111.25	50.88	0.38	0.48	0.36	0.99	11.48	4.80	0.13	0.08
25	111.25	52.65	0.30	0.38	0.20	0.86	11.96	4.78	-0.03	-0.08
	133.50	57.63	0.38	0.51	0.36	1.12	14.55	5.97	0.03	0.10
1	133.50	67.41								
2	133.50	70.84								
3	133.50	73.96								
4	133.50	76.53								
5	133.50	79.22	0.38	0.58	0.43	1.42	20.70	7.77	0.36	0.15
6	133.50	81.05								
7	133.50	83.29								
8	133.50	84.40								
9	133.50	85.67								
10	133.50	86.84	0.38	0.53	0.36	1.47	23.50	8.33	0.25	0.03
11	133.50	90.27	0.46	0.69	0.51	1.65	24.99	8.84	0.48	0.15
	155.75	99.95	0.46	0.69	0.53	1.78	29.92	10.36	0.51	0.18
1	155.75	111.99								
2	155.75	115.80								
RESET	155.75	115.80								
4	142.40	124.87	0.36	0.61	0.48	1.91	37.57	11.91	0.48	0.15
	133.50	127.00								
	89.00	123.82								
	44.50	117.48								
UNLOAD	0.00	107.95								

NOTE: (*) POSITIVE VALUES INDICATE SOIL UPLIFT MOVEMENTS MEASURED BY TELL-TALES

TABLE C3 RESULTS OF FIELD LOAD TESTING OF GRILLAGES

TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. D (NORTHEAST LEG) JAN. /89
TOWER NO. 15
UPLIFT LOAD TEST

HOLD TIME (MIN.)	LOAD (kN)	FOOTING DEFLN (mm)	VERTICAL TELL-TALES ## T1 (mm)	T2 (mm)	T3 (mm)	T4 (mm)	T5 # (mm)	T6 (mm)	T7 (mm)	T8 (mm)
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	13.34	1.12	0.03	0.03	0.05	0.03	0.00	0.00	0.00	-0.03
	22.24	2.08	0.00	0.00	0.03	0.03	0.10	0.00	0.00	-0.03
	33.36	3.91	0.00	0.00	0.03	0.03	0.99	0.00	0.03	0.03
	44.48	6.40	0.00	0.00	0.03	0.08	2.54	0.00	0.03	-0.05
1	44.48	7.29								
2	44.48	7.72								
3	44.48	8.00								
4	44.48	8.20								
5	44.48	8.36	-0.03	0.00	0.03	0.10	3.91	0.08	0.08	0.08
	55.60	10.46	-0.03	0.00	0.05	0.15	5.64	0.43	0.10	0.05
1	55.60	12.37								
3	55.60	13.74								
4	55.60	14.12								
5	55.60	14.45	-0.05	0.00	0.03	0.20	8.38	0.99	0.08	0.05
	66.72	16.46	-0.08	-0.03	0.03	0.23	10.24	1.42	0.10	0.08
1	66.72	18.82								
2	66.72	20.32								
3	66.72	21.64								
4	66.72	22.43								
5	66.72	22.96								
6	66.72	23.52	0.00	0.05	0.05	0.28	14.88	2.31	0.15	0.13
	20.02	20.04	0.03	0.08	0.13	0.33	13.18	1.70	0.13	0.15
	46.70	21.82	0.05	0.10	0.10	0.28	13.82	1.88	0.10	0.05
	66.72	24.77	0.05	0.10	0.13	0.36	15.27	2.41	0.20	0.20
1	66.72	25.96								
2	66.72	26.72								
3	66.72	27.18								
4	66.72	27.53								
5	66.72	27.84	0.05	0.10	0.13	0.41	15.85	2.77	0.13	0.08
	77.84	30.61	0.08	0.13	0.15	0.43	16.79	3.33	0.30	0.30
1	77.84	35.05								
2	77.84	36.58								
3	77.84	37.90								
4	77.84	39.22								
5	77.84	40.03	0.05	0.13	0.15	0.58	18.57	4.52	0.25	0.10
6	77.84	40.84								
7	77.84	41.55								
8	77.84	42.19								
9	77.84	42.75								
10	77.84	43.33	0.08	0.13	0.15	0.66	19.15	5.05	0.30	0.20
11	77.84	43.92								

TABLE C3 RESULTS OF FIELD LOAD TESTING OF GRILLAGES
(Cont'd)
TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. P (NORTHEAST LEG) JAN. /89
TOWER NO. 15
UPLIFT LOAD TEST

HOLD TIME (MIN.)	LOAD (kN)	FOOTING DEFLN (mm)	VERTICAL TELL-TALES ** T1 (mm)	T2 (mm)	T3 (mm)	T4 (mm)	T5 * (mm)	T6 (mm)	T7 (mm)	T8 (mm)
12	77.84	44.40								
13	77.84	44.98								
14	77.84	45.52								
15	77.84	45.87	0.20	0.25	0.23	0.81	19.61	5.46	0.36	0.28
RESET	77.84	45.87								
	88.96	49.43	0.36	0.33	0.33	0.97	20.65	6.30	0.49	0.36
1	88.96	53.38								
2	88.96	56.36								
3	88.96	58.45								
4	88.96	59.92								
5	88.96	61.57	0.46	0.58	0.61	1.40	-	8.38	0.79	0.58
6	88.96	63.02								
7	88.96	63.88								
8	88.96	64.95								
9	88.96	66.01								
10	88.96	67.03	0.43	0.53	0.56	1.40	-	9.09	0.76	0.58
12	88.96	69.58								
13	88.96	69.29								
14	88.96	69.98								
15	88.96	70.64	0.43	0.53	0.53	1.40	-	9.55	0.76	0.56
16	88.96	71.30								
17	88.96	71.86								
18	88.96	72.44								
19	88.96	72.97								
20	88.96	73.53	0.41	0.51	0.48	1.40	-	9.91	0.74	0.46
21	88.96	74.22								
22	88.96	74.63								
23	88.96	75.11								
24	88.96	75.56								
25	88.96	76.10	0.20	0.23	0.20	1.17	-	10.08	0.58	0.46
	100.08	80.11	0.08	0.15	0.10	1.09	-	10.67	0.56	0.43
1	100.08	82.88								
2	100.08	84.53								
3	100.08	85.93								
4	100.08	87.30								
5	100.08	88.67	0.28	0.25	0.20	1.17	-	11.91	0.58	0.46
6	100.08	89.84								
7	100.08	90.78								
8	100.08	91.67								
9	100.08	92.56								
10	100.08	93.62	0.38	0.38	0.38	1.40	-	12.78	0.69	0.51
11	100.08	94.34								
12	100.08	95.15								
13	100.08	95.83								
14	100.08	96.60								
15	100.08	97.38	0.46	0.56	0.51	1.60	-	13.41	0.79	0.58
16	100.08	97.92								
17	100.08	98.81								
18	100.08	99.52								
19	100.08	100.28								
20	100.08	101.14								
21	100.08	101.75	0.48	0.53	0.48	1.57	-	13.97	0.79	0.58
23	100.08	102.97								
24	100.08	103.53								
25	100.08	104.24	0.51	0.51	0.48	1.57	-	14.27	0.79	0.61
RESET	100.08	104.24								

TABLE C3 RESULTS OF FIELD LOAD TESTING OF GRILLAGES
(Cont'd)
TL REFURBISHMENT - OAKVILLE SECTION 115 kV
FOOTING NO. D (NORTHEAST LEG) JAN. /89
TOWER NO. 15
UPLIFT LOAD TEST

HOLD TIME (MIN.)	LOAD (kN)	FOOTING DEFLN (mm)	VERTICAL TELL-TALES (**) T1 (mm)	T2 (mm)	T3 (mm)	T4 (mm)	T5 (*) (mm)	T6 (mm)	T7 (mm)	T8 (mm)
	111.20	108.15	0.58	0.64	0.71	1.73	-	15.24	0.99	0.71
1	111.20	111.99								
2	111.20	115.29								
3	111.20	118.01								
4	111.20	120.12								
5	111.20	122.07	0.61	0.71	0.69	1.88	-	17.63	0.97	0.74
6	111.20	124.10								
7	111.20	125.25								
8	111.20	127.03								
9	111.20	128.19								
10	111.20	129.51	0.71	0.81	0.81	2.03	-	19.08	1.07	0.81
11	111.20	130.76								
12	111.20	131.85								
13	111.20	132.77								
14	111.20	133.71								
15	111.20	134.19	0.74	0.81	0.81	2.03	-	19.84	1.09	0.84
	111.20	136.53								
	88.96	136.53								
	66.72	134.94								
	44.48	131.76								
	22.24	128.59								
	0.00	120.65								
UNLOAD	0.00	115.77	0.76	0.79	0.89	1.63	-	14.88	0.91	0.76

NOTE: (*) VERTICAL TELL-TALE NO. T5 DROPPED APPROXIMATELY 50 mm INTO VOID DURING UPLIFT TEST

(**) POSITIVE VALUES INDICATES SOIL UPLIFT MOVEMENTS MEASURED BY TELL-TALES